IRP 81-04

VOL III OF V

ASSESSMENT OF ENVIRONMENTAL CONTAMINATION EXPLORATORY STAGE TOOELE ARMY DEPOT TOOELE, UTAH

VOLUME III APPENDICES B THROUGH E

IRP 81-04

ASSESSMENT OF ENVIRONMENTAL CONTAMINATION VOL III, APPENDIX B-E

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3 OF 5

ASSESSMENT OF ENVIRONMENTAL CONTAMINATION EXPLORATORY STAGE TOOELE ARMY DEPOT TOOELE, UTAH

VOLUME III APPENDICES B THROUGH E

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CONTRACT NO.: DAAG49-81-C-0192

Submitted to:

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PROCUREMENT DIVISION
P.O. BOX D
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AND
U.S. ARMY TOXIC AND HAZARDOUS
MATERIALS AGENCY
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Appendix B

Methodology for Phase II Technical Effort

B-1 Methodology for Well Installation

B-1.1 Drilling Operations

Monitoring wells for the TEAD Environmental Survey were drilled using hollow stem auger, mud rotary, and cable tool techniques. Drilling contractors were F.M. Fox and Associates, Denver, Colorado for the hollow stem auger and Scott Stephenson Drilling, Fillmore, Utah for the mud rotary and cable tool.

Ten wells and two borings in the South Area were completed using the hollow stem auger; one boring (S-9) was discontinued at a depth of 111 feet, and was capped. One well (N-8A) and one boring (N-2A) in the North Area were drilled with the hollow stem auger.

Drilling procedures were followed as outlined in the Technical Plan. The major exception was that a 6 7/8-inch hole, rather than a 10-inch hole was drilled at most sites. It was determined that if caving were not a problem, it was more efficient to drill a smaller hole, remove the auger, and then install the casing, because the drilling efficiency of the larger auger decreased rapidly at depths greater than 40 feet. If caving was a problem, the hole was drilled with the smaller auger, reamed with the larger auger, and the casing was installed through the hollow stem.

Difficulties forcing bore abandonment were encounterd at three locations: N-2A, S-15, and S-9. Large quartzite boulders and cobbles halted drilling at N-2A and S-15. S-9 was abandoned due to sticky clay and the limit of the auger capabilities. Upon completion of the field program assessment, it was determined that it was unnecessary to complete these wells.

Split spoon samples were taken every 5 feet and were described by the Ertec hydrogeologist in accordance with USATHAMA requirements. Exceptions to the sampling intervals occurred when drilling through gravels in which there was auger refusal.

Four wells in the North Area were drilled using the mud rotary technique. These wells ranged in depth from 65 feet (N-3B) to 709 feet (N-6). Drilling procedures were followed as outlined in the Technical Plan. Rotary wash samples were obtained over 1-foot intervals every 5 feet, i.e., the hole was circulated with mud for approximately ten minutes after drilling 5 feet, to ensure that most of the cuttings were removed and then the sample was collected during the drilling of the next foot. At 15-foot intervals (the end of each drill rod), the drill stem was removed and a split spoon sample was attempted. Exceptions occurred when the drilling proceeded through gravels, in which case it was impossible to recover a sample. The split spoon sampler was driven using 600 pound cable tool jars. All samples were collected and logged by the Ertec hydrogeologist in accordance with USATHAMA requirements, as set forth in the Ertec field manual and in Appendix C (revised) of the original proposal for this project.

Major drilling problems encountered were lost circulation, caving, and zones consisting of large quartzite boulders and cobbles. Generally, circulation was regained by thickening the mud, but in one case (N-3A), circulation loss was so extreme (thousands of gallons) that it was necessary to use mica flakes as lost circulation material. At N-6, circulation loss and caving were severe enough that rotary drilling could not continue past 30 feet. This necessitated drilling with a cable tool rig and setting surface casing to a depth of 100 feet before drilling was resumed with the rotary rig. At N-7 3600 gallons of mud were lost in the first 4 feet of drilling. N-7 was then also started with the cable tool rig.

Large quartzite boulders and cobbles presented the most challenging problem for the rotary rig. This lithology was previously undocumented at TEAD, except for some shallow holes drilled by the U.S. Army Environmental Hygiene Agency near the North Area Industrial Waste Pond in August, 1981. The depths, extents, and drilling difficulties in these materials were unknown, and therefore unanticipated. These boulders were extremely hard, and there was little fine material between them. Therefore, a natural sieve was created, drilling mud was lost, and drill bits were very quickly worn down. The use of the rotary rig became very inefficient, and it was for this reason that the cable tool rig was employed.

The cable tool rig was used to drill two wells in the North Area (N-2C and N-4). Two wells were started with the cable tool (N-6 and N-7). N-6 was later completed with the rotary rig, and drilling on N-7 was stopped at 75 feet, when this well was deleted from the drilling program. N-2B was drilled to 65 feet where bedrock was penetrated. S-1 was also drilled with the cable tool because flooding at this drill site prohibited the use of the auger rig before the auger program was completed. When access to the drill site was available, the cable tool was the only rig still at TEAD.

Samples of drill cuttings from the bailer used in drilling operations were collected continuously when drilling with the cable tool. Split spoon samples were obtained when feasible by driving the sample with the cable tool jars. Surface casing driven by the cable tool was removed from wells N-2C and N-4. Surface casing was left in N-2B, N-6, and N-7. Numerous attempts to remove the surface casing from N-2B failed. The casing was left in N-6 and N-7 to prevent further caving; it is above the water table in both bores.

B-1.2 Well Construction

Well construction procedures were followed as outlined in the Technical Plan. The major exceptions were the use of 4.5 inch O.D. Schedule 40 polyvinyl chloride (PVC) rather than 4-inch O.D. Schedule 80 PVC and that Well N2C was completed with 2-inch O.D. Schedule 40 PVC casing. Table 1 lists the construction materials, and source or supplier of materials.

N-2C was the only well to be completed as a 2-inch diameter well. It originally had been constructed as a 4.5 inch well, but when well development commenced, the 3.75-inch bailer was unable to proceed past a depth of 20 feet. Upon inspection by the Ertec field hydrogeologist, it was observed that there was a bulge in the PVC, prohibiting the passage of the bailer. This bulge occurred at a flush-threaded joint. It is not known if this was caused by a defect in the PVC. A crack was also observed, therefore a decision was made to recase the well with 2 inch PVC and emplace a second gravel pack and bentonite seal. It was determined that this method was more cost-effective than drilling a new well while still providing an uncompromised sample for chemical analysis.

All lithologic summaries, well construction summaries, and geophysical logs for wells and bores are found in Appendix C.

B-1.3 Well Development

Well development was generally completed following the procedures outlined in the Technical Plan. Wells in the South Area were not drilled with mud, and the aquifer material consisted of very fine grained silts and sands. Therefore, most of these wells were very particulate-laden, and in many cases the transmissivity was so low that the well could be bailed dry very easily.

Table 1. Well Construction Materials

Material	Brand	Source/Supplier
PVC Casing	4.5 inch O.D.-Schedule 40, flush-threaded/2.0 inch O.D.-Schedule 40, flush threaded	Timco Mfg., Prairie du Sac, Wisconsin
PVC Screen	.050 slot, 4.5 inch O.D.-Schedule 40, flush threaded/ 2.0 inch O.D.-Schedule 40, flush threaded	Timco Mfg., Prairie du Sac, Wisconsin
Bentonite (drilling fluid)	Aquagel	NL Baroid, Evanston, Wyoming
Bentonite (granular)	Big Horn	Nova Mud, Orem, Utah
Bentonite (pellets)	--	Nova Mud, Orem, Utah
Gravel/sand pack	8-12 silica sand	Colorado Silica Sand, Colorado Springs, Colorado/ supplier-Vinton Pipe Co., Salt Lake City, Utah
Cement	Portland Type II "Utah Cement"	Ideal Basic Industries, Salt Lake City, Utah

For these wells, the development method consisted of bailing the well dry, allowing full recovery and bailing dry again. This method was repeated a minimum of five times for each well. If it appeared that a well could recover fairly rapidly (a minimum of 2 gallons per minute), a submersible pump was used for further development. The well was then pumped for a minimum of two hours, and pH, Ec, temperature, and sand content were monitored as outlined in the Technical Plan. Table 2 shows the method of development and the amount of water removed from each well.

All wells drilled by the mud rotary techniques were bailed until the well was free of drilling mud. Pump tests were conducted with the use of a submersible pump and appropriate field parameters were recorded.

At Well N-6, the well was continually bailed dry, and it was believed that the mud cake used to prevent lost circulation was too thick to allow for proper well development. Attempts to clean the well using drilling water from existing Well #1 failed, and upon USATHAMA approval, 100 pounds of sodium acid pyrophosphate (SAPP), a dispersing agent, were added to the well. The well was surged repeatedly with a bailer, but most recent water level measurements (June 1982) indicate that the well is dry.

B-2 Methodology for the Collection of Soil, Sediment, and Surface-Water Samples

B-2.1 Soil Samples

Soil samples used for chemical analysis were collected from borings using a split spoon sampler. The spoons were cleaned carefully with a wire brush, rinsed repeatedly in distilled water, and wiped dry with a clean dry rag prior to sampling. Samples were taken in borings installed with the auger by attaching the spoon to an A-rod, lowering it down the center of the hollow

Table 2. Well Development

Well	Development Method	Total Amount of Water Removed (gallons)	Date Development Completed
S-1	pump, 18 gpm	2840	6/1/82
S-2	bail/pump; 1 gpm	482	4/20/82
S-3	bail/pump; 12 gpm	1110	4/18/82
S-4	bail -	216	4/20/82
S-5	bail/pump; 11 gpm	1980	4/18/82
S-6	bail -	104	4/19/82
S-7	bail -	151	4/20/82
S-8	bail -	103	4/20/82
S-10	bail/pump; 4 gpm	842	4/19/82
S-12	bail -	36	4/20/82
S-14	bail/pump; 9 gpm	985	4/18/82
N-2C	pump; 1 gpm	45	6/12/82
N-3A	pump; 15 gpm	3843	6/17/82
N-3B	bail -	46	6/4/82
N-4	bail/pump; 6 gpm	770	6/3/82
N-6	bail -	dry	4/20/82
N-8B	bail/pump; 18 gpm	7298	3/2/82

stem auger and driving it into the soil. Upon removal of the spoon, we carefully inspected the contents, removed the upper 6 inches (or more) of slough, scraped the sides of the sample with a stainless steel blade to remove smear, and placed portions of the sample in a wide-mouth amber glass jar with a Teflon-lined plastic lid. Samples were immediately placed on ice and sent to the lab within 48 hours of collection. Samples were obtained in this manner from Wells S-1, S-2, and S-8 and from Boring S-11. The 11 split spoon samples from Well N-3A were taken with a slightly modified procedure using a down-hole hammer to drive the sample. These borings were drilled by the mud rotary method. Also, greater care was taken in removing the sample from the spoon as drilling mud sometimes contaminated a portion of the sample. The initial sample from Well N-3A was taken as a grab sample. A soil sample from the proposed site of N-1 also was taken as a grab sample. Although N-1 was deleted from the drilling program, the sample was analyzed, and labelled N-1, GS1. Table 1 lists the soil samples collected for chemical analysis.

B-2.2 Sediment Samples

Eight samples of sediment were collected for chemical analysis, four from the TEAD North Area, and four from the TEAD South Area. In the Technical Plan, it was proposed that sediment samples be taken at points immediately downslope from the locations of surface water samples. With the exception of sample N-SD3, which was collected immediately below the location of N-SW2 (the industrial waste pond), it was determined by field personnel that this method was not feasible for the remaining sediment samples as there was no surface water flow at the sample locations.

For the remaining seven locations, the proposed sampling site was inspected by field personnel for fine-grained materials which were likely to have been

Table 1. Soil Samples for Chemical Analysis

Site I.D.	Site Type	Field Sample No.	Sample Depth (Feet)	Sample Method	Date Collected
N-3A	Well	GS-1	1.0	Grab	2/27/82
N-3A	Well	SS-3	10.75	Split spoon	2/27/82
N-3A	Well	SS-5	20.75	Split spoon	2/27/82
N-3A	Well	SS-7	30.75	Split spoon	2/27/82
N-3A	Well	SS-9	40.75	Split spoon	2/27/82
N-3A	Well	SS-11	50.75	Split spoon	2/27/82
N-3A	Well	SS-13	60.75	Split spoon	2/27/82
N-3A	Well	SS-15	70.75	Split spoon	2/27/82
N-3A	Well	SS-17	80.75	Split spoon	2/27/82
N-3A	Well	SS-19	90.75	Split spoon	2/27/82
N-3A	Well	SS-22	100.15	Split spoon	2/27/82
N-3A	Well	SS-30	138.75	Split spoon	2/27/82
S-2	Well	SS-2	5.5	Split spoon	2/19/82
S-2	Well	SS-6A	25.3	Split spoon	2/19/82
S-2	Well	SS-10	45.75	Split spoon	2/19/82
S-8	Well	SS-4	15.7	Split spoon	3/02/82
S-8	Well	SS-9	40.75	Split spoon	3/02/82
S-8	Well	SS-12	55.75	Split spoon	3/02/82
S-8	Well	SS-14	65.55	Split spoon	3/02/82
S-8	Well	SS-17	80.55	Split spoon	3/02/82
S-11	Bore	CS-1	17.45	Split spoon	2/22/82
S-11	Bore	CS-2	36.95	Split spoon	2/22/82
S-11	Bore	SS-16	76.25	Split spoon	2/22/82
S-1	Well	SS-2	5.75	Split spoon	5/27/82
S-1	Well	SS-3	10.6	Split spoon	5/27/82
S-1	Well	SS-4	15.6	Split spoon	5/27/82
S-1	Well	SS-5B	20.7	Split spoon	5/27/82

stream-deposited. Three of the proposed sampling sites in the North Area (the dry wash entering the south boundary near N-7, South Willow Creek, and the mouth of the unnamed wash near N-8) were eliminated because there was no evidence of recent sediment deposition. These sites were replaced by taking sediment samples from the industrial waste pond (N-SD3), and the radioactive waste storage area (N-SD4).

Sediment samples were taken with a stainless-steel spade, which was cleaned carefully with paper towels and then rinsed thoroughly with distilled water. Samples were taken from a depth of approximately 3 to 5 inches below ground surface. Samples were placed in wide mouth amber glass jars with Teflon-lined plastic lids, were stored at 4°C, and were sent to the laboratory within 48 hours of collection. Sampling locations were marked with 4-foot wooden stakes painted fluorescent orange.

Table 2 is a list of sediment samples taken for chemical analysis.

B-2.3 Surface-Water Samples

Six surface water samples, three from the North Area and three from the South Area were collected for chemical analysis. The samples were all from standing water or depot effluents; no flowing streams were found at this time.

Samples were collected by partially immersing the containers in standing or flowing water. The types of containers and preservatives used are listed in Section B-4. Care was taken to prevent loss of preservative.

Field temperature, pH, Eh, and specific conductance were measured for all surface water samples. Because most samples consisted of standing water from ponds or lagoons, or the flow was very low, these measurements were not taken

Table 2. Sediment Samples for Chemical Analysis

Site I.D.	Site Type	Field Sample No.	Sample Depth (ft)	Sample Method	Date Collected
N-SD1	Ditch	N-SD1	0.5	Grab	4/3/82
N-SD2	Ditch	N-SD2	0.5	Grab	4/3/82
N-SD3	Pond	N-SD3	0.5	Grab	4/4/82
N-SD4	Ditch	N-SD4	0.5	Grab	5/26/82
S-SD1	Ditch	S-SD1	0.5	Grab	4/4/82
S-SD2	Ditch	S-SD2	0.5	Grab	4/4/82
S-SD3	Ditch	S-SD3	0.5	Grab	4/4/82
S-SD4	Ditch	S-SD4	0.5	Grab	4/4/82
N-1	Surface	GS-1	0.75	Grab	4/4/82

in situ. Instead, a beaker was rinsed out several times with a sample of surface water, and then a portion was obtained to thermally equilibrate the buffer solutions. A fresh sample was then obtained for the actual field measurement.

Samples were stored at 4°C immediately, and delivered to the laboratory within 48 hours of collection. Table 3 is a list of the surface water samples collected for analysis.

B-3 Methodology for the Collection of Ground-water Samples

B-3.1 General

Ground-water samples were collected using one of the following techniques: 1) bailing the well using a stainless steel and teflon bailer; 2) pumping the well using a nitrogen-driven double-acting piston pump made of stainless steel and Teflon (the Bennett pump); or 3) pumping the well by means existing pumps in water supply wells. This latter case occurred for the seven existing wells that we sampled on the Depot. We had no control over pump or casing materials, or over drilling and construction methods. Therefore, a lower degree of confidence is placed on the analytical results obtained for the existing wells than on those obtained for newly constructed monitoring wells.

Ensuring that representative aquifer samples could be obtained is an extremely important part of the ground-water sampling procedure. We employed several approaches in determining whether sufficient water had been evacuated from the well to produce a proper sample. Generally, procedures developed by Ertec for USATHAMA for the Rocky Mountain Arsenal sampling program were followed. In the South Area this was not a critical problem. All wells were pumped dry repeatedly during development because the transmissivity of the aquifer zones

Table 3. Surface-Water Samples for Chemical Analysis

Site I.D.	Site Type	Field Sample No.	Sample Depth (Feet)	Sample Method	Date Collected
N-SW1	Pond	N-SW1	0.5	Grab	4/5/82
		N-SW1R	0.5	Grab	6/23/82
N-SW2	Pond	N-SW2	0.5	Grab	4/14/82
N-SW3	Lagoon	N-SW3	0.5	Grab	6/23/82
S-SW1	Pond	S-SW1	0.5	Grab	4/6/82
		S-SW1R	0.5	Grab	6/24/82
S-SW2	Standing Water	S-SW2	0.5	Grab	4/15/82
S-SW3	Ditch	S-SW3	0.5	Grab	5/4/82

penetrated by the wells in this area is rather low. Since drilling fluids were not used during drilling or construction of any of these wells, pumping the wells dry guarantees recovery of 100 percent aquifer water. However, since these wells, for the most part, were not sampled within one day after being pumped dry, there is a possibility that some of the more highly volatile contaminants might have been lost. Therefore, wells that were not pumped dry within 24 hours of being sampled were closely monitored using flow-through cell procedures. This has been the case for wells in the North Area and all existing wells. The flow-through cell, discussed at length in the technical plan, allows for the measurement of pH, Eh (oxidation-reduction potential), EC (electrical conductivity), and temperature without allowing exposure to oxygen in the air and the subsequent chemical changes that immediately would occur. These parameters were monitored carefully while water was being evacuated from each well. When readings stabilized sufficiently to ensure that pumped water was representative aquifer water, samples were collected. Immediately following sample collection, parameters were again monitored to note any changes that might have occurred. If significant changes occurred in any of the parameters, the well was resampled when the parameters again stabilized. Table 1 lists the wells sampled along with method and date of sampling and amount of water evacuated before the sample was collected.

Ground-water samples at each site were collected in a series of nine sampling containers supplied by UBTL. These containers were pre-packaged with preservatives added by the lab. The type of container and preservative added for specific analytes are included in Appendix B-4. The only filtering done in the field was for the sample used for metals analyses. Filtering was accomplished using a Geofilter filter apparatus with 0.45 m filters. All samples were

Table 1. Ground-water Sampling

Well No.	Volume of Water Evacuated: No. Casing Volumes	Volume of Water Evacuated: Gallons	Date Sampled	How Sampled
NORTH AREA				
Well 1	>10*	>1000	3/30/82	existing pump
Well 2	>10*	>1000	3/30/82	existing pump
Well 4	>10	2750	3/31/82	existing pump
Well 5	16	1500	4/14/82	existing pump
Well 6	>10*	> 250	4/4/82	existing pump
N-2C	dry	24	6/24/82	Bennett pump
N-3A	0.5	36	4/5/82	Bennett pump
N-3B	dry	2.6	6/23/82	Bailed
N-4	2.2	40	6/24/82	Bennett pump
N-8B (1)	0.9	39	5/3/82	Bennett pump
N-8B (2)	0.7	38	5/3/82	Bennett pump
SOUTH AREA				
Well 1	>10*	>1000	3/31/82	existing pump
Well 3	>16	8540	4/15/82	existing pump
S-1	2.5	27	6/24/82	Bennett Pump
S-2	1.3	22	4/29/82	Bennett Pump
S-3	3.2	44	4/29/82	Bennett Pump
S-4	dry	21	5/2/82	Bailed
S-5	1	16	5/2/82	Bennett Pump
S-6	dry	76	4/28/82	Bennett Pump
S-7	1	21	5/3/82	Bennett Pump
S-8	dry	8.6	5/3/82	Bennett Pump
S-10	1	15.4	5/2/82	Bennett Pump
S-12	dry	13.2	4/28/82	Bennett Pump
S-14	3	51	5/2/82	Bennett Pump

* pumped regularly for Depot use

collected using teflon tubing. The sampling procedure was amended slightly during the sampling program to improve sample quality for the metals samples. Instead of supplying preservative spiked sample containers for this sample, the laboratory supplied reagent grade concentrated nitric acid which was added to the sample after collection. This prevented leaching of nickel and zinc from the sample bottles. Such leaching was found to cause significant nickel and zinc in the blank samples analyzed during the qualitative procedures used by the laboratory.

At the time of sample collection, blanks and duplicates also were included for QC purposes. A duplicate sample was taken when sampling existing Well No. 2 in the North Area. As part of the field quality control, a blank, consisting of distilled water and preservatives supplied by the laboratory, accompanied the sampling of existing well USGS No. 2. Upon sampling for each analyte, this blank container would be opened while sampling and resealed immediately after sampling was completed. The blank and duplicate were sent to the lab and analyzed along with the collected samples.

B-3.2 Existing Wells

Of the six existing wells in the North Area, the five with pumps were sampled. Well No. 3, located in the Maintenance and Supply Area, did not have a pump. This well was not sampled for two reasons: 1) it is located centrally between Wells 1 and 2, and is close enough to these two wells to be considered superfluous; and 2) because of its large diameter, it contains too much water to evacuate with a small volume pump before a representative aquifer sample could be collected.

Of the three existing wells in the South Area, only two were sampled. Well No. 2 was not sampled because of its close proximity to Well No. 1.

Sampling methodology for these existing wells consisted of:

a. Obtaining the proper fittings to tap into the discharge line ahead of the chlorinator.

b. Running the discharge through teflon tubing into the flow-through cell to monitor pH, Eh, EC, and temperature properly.

c. Pump the well sufficiently long to evacuate the required amount of water.

d. Collect the sample in proper sampling container; preserve, filter, store, and ship to lab.

e. Proper cleaning of tubing, filter apparatus, and fittings.

B-3.3 Wells Sampled by Bailer

Because of very slow recharge and high suspended solids content, a stainless steel and teflon bailer was used to collect ground-water samples from Wells S-4 and N-3B. The procedure for sampling these wells was modified considerably since continuous monitoring could not be accomplished. After thoroughly cleaning the bailer with soapy water, acetone, and repeated distilled water rinses, we carefully lowered it into the well with a stainless steel wire. The bailer then was drawn out of the well and the water poured into a container to be disposed of after sampling was completed. This was repeated until enough water was removed from the well to ensure a minimum loss of volatile constituents from the water remaining to be sampled. Eh, pH, EC, and temperature were monitored periodically from the bailer samples. After a sufficient volume of water was evacuated from the well, samples were collected by carefully decanting the water into the sample containers. Special care was taken when collecting the sample for volatile organics in that the sample was collected after decanting the initial third of the water from the bailer and only using the interior third. The metals sample was filtered directly from the bailer using new teflon tubing for each sample. Three bailer volumes were required to obtain the required volume for the metals samples.

B-3.4 Wells Sampled Using the Bennett Pump

The Bennett pump is an all stainless steel and teflon positive displacement pump using nitrogen to drive a double-acting piston which delivers a steady stream of water at the rate of 1/2 gallon per minute from depths as great as 625 feet. The only materials that contact water are stainless steel and Teflon. This pump was used in all monitoring wells except those bailed as discussed in the previous section. After thorough cleaning with soapy water, acetone, and repeated distilled water rinses, we carefully lowered the pump down the well until the water level indicator sounded. The well was then pumped from approximately 2 feet below the surface until the pH, Eh, EC, and temperature stabilized. The pump was lowered gradually as the water level dropped. At this time the samples were taken. Eh, pH, EC, and temperature were again measured after samples had been obtained. If significant differences in any of the readings had occurred, the well would be resampled after stabilization of Eh, pH, Ec, and temperature. After use the pump was cleaned by the same procedure used prior to sampling.

This sampling procedure was modified slightly for two wells in the North Area, Well N-3A and Well N-8B. In these wells the pump was lowered to a position in the center of each screened interval. The well was then pumped until monitoring parameters stabilized and a sample then was taken. From Well N-8B two samples were taken using this procedure because there are two sets of screens that are open to two separate aquifer zones.

B-4 Methodology for Chemical Analyses

All laboratory analyses were performed by Utah Biomedical and Testing Laboratory (UBTL) of Salt Lake City, Utah, except for radiological analyses which were performed by Controls for Environmental Pollution (CEP), Los Alamos, New Mexico, under supervision and control of UBTL. This section summarizes the laboratory protocols, analytical methods, and quality control used by UBTL for the Tooele Army Depot Survey. Table 1 is a project summary, Table 2 summarizes analyses by lot, and Table 3 is a summary of lots by analysis.

Table 1.
Project Summary

Project Title	UBTL Project Director
Chemical Analysis for Tooele Army Depot Contract No. DAAG 49-81-C-0192	Sim D. Lessley, Ph.D.

Progress Summary: Samples	Jan	Feb	Mar	Apr	May	Jun	Jul
Number of Certification Samples Analyzed*	56	16	8	0	4	0	0
Number of Water Samples Received	0	0	3	15	9	6	0
Number of Soil Samples Received	0	6	17	8	0	5	0
Number of Soil Leach Tests Performed	0	6	17	8	0	5	0
Number of Soil Leach Samples Generated	0	48	70	64	0	33	0
Number of Field Samples Analyzed by Method:							
Volatiles	0	0	0	10	13	0	7
Semi Volatiles	0	0	12	6	0	27	10
Explosives	0	0	6	25	25	4	5
NG and PETN	0	0	23	8	25	9	0
Oil and Grease	0	0	0	0	25	0	5
Metals - ICP	0	0	6	0	6	20	22
Metals - GF/AA	0	0	12	20	13	0	9
Mercury	0	0	12	20	13	6	4
Sodium	0	0	6	26	13	0	9
Anions	0	3	9	24	9	9	0
Cyanide	0	0	0	0	25	0	5
Gross Alpha and Beta	0	0	0	0	0	47	10
Total Number of Field Samples Analyzed	0	3	86	139	167	122	86
Number of QC Spikes Analyzed	0	1	16	37	20	19	27
Number of QC Blanks Analyzed	0	2	25	33	16	22	18
Total Number of Samples Analyzed (Field & QC)	0	6	127	209	203	163	131

*Note eighteen additional recertification samples were analyzed in September 1982.

Table 2.

Summary of Analyses by Lot

Lot	Matrix	Analysis	Date Analyzed	Field Samples	QC Samples	Blanks	Total Samples
AAA	Leach	Anions	02/26/82	3	1	1	5
AAB	Leach	Anions	03/01/82	3	1	1	5
AAC	Leach	NG & PETN	03/05/82	6	1	2	9
AAD	Leach	5 Explosives	03/10/82	6	1	2	9
AAE	Leach	Semi Volatiles	03/12/82	6	1	2	9
AAF	Leach	Mercury	03/05/82	6	1	2	9
AAG	Leach	Metals-ICP	03/11/82	6	2	2	10
AAH	Leach	Anions	03/05/82	5	1	1	7
AAI	Leach	Metals GF/AA	03/16/82	6	1	2	9
AAJ	Leach	Sodium	03/10/82	6	1	2	9
AAK	Leach	Mercury	03/11/82	6	1	2	9
AAL	Leach	Anions	03/11/82	1	1	1	3
AAM	Leach	NG & PETN	03/17/82	11	1	1	13
AAN	Leach	NG & PETN	03/17/82	6	1	1	8
AAO	Leach	5 Explosives	04/01/82	11	1	1	13
AAP	Leach	5 Explosives	04/01/82	6	1	1	8
AAQ	Leach	Semi Volatiles	03/18/82	6	1	2	9
AAR	Leach	Sodium	04/07/82	6	1	2	9
AAS	Leach	Metals GF/AA	03/25/82	6	1	2	9
AAT	Leach	Metals ICP	05/13/82	6	2	2	10
AAU	Water	Anions	04/03/82	4	2	1	7
AAV	Water	Anions	04/06/82	2	1	1	4
AAW	Water	Volatiles	04/06/82	4	7	0	11
AAX	Water	Volatiles	04/06/82	2	3	2	7
AAY	Water	Mercury	04/07/82	6	2	1	9
AAZ	Water	Semi Volatiles	04/29/82	6	2	1	9

Lot	Matrix	Analysis	Date Analyzed	Field Samples	QC Samples	Blanks	Total Samples
ABA	Water	Anions	04/07/82	2	1	0	3
ABB	Water	NG & PETN	04/13/82	8	2	0	10
ABC	Water	5 Explosives	04/16/82	8	2	0	10
ABD	Water/Leach	Anions	04/16/82	12	2	4	18
ABE	Water	Mercury	04/20/82	14	2	6	22
ABF	Water	Volatiles	04/21/82	4	1	1	6
ABG	Water/Leach	NG & PETN	05/05/82	12	2	4	18
ABH	Water/Leach	Explosives	05/10/82	12	2	4	18
ABI	Water/Leach	Semi Volatiles	06/08/82	14	2	4	20
ABJ	Water/Leach	Metals GF/AA	04/28/82	20	3	5	28
ABK	Water	Sodium	04/28/82	20	3	7	30
ABL	Water/Leach	Metals ICP	06/03/82	20	4	5	29
ABM	Water	Cyanide	05/05/82	12	3	2	17
ABN	Water	Oil & Grease	05/06/82	12	2	2	16
ABO	Water	Anions	04/30/82	4	1	0	5
ABP	Water	Anions	05/04/82	4	1	0	5
ABQ	Water	Anions	05/06/82	5	1	0	6
ABR	Water	Cyanide	05/11/82	13	1	0	14
ABS	Water	Mercury	05/07/82	13	1	0	14
ABT	Water	Semi Volatiles	06/24/82	13	1	0	14
ABU	Water	Volatiles	05/06/82	13	1	0	14
ABV	Water	5 Explosives	05/22/82	13	1	0	14
ABW	Water	NG & PETN	05/27/82	13	1	0	14
ABX	Water	Oil & Grease	05/11/82	13	0	0	13
ABY	Water	Sodium	05/12/82	13	1	1	15
ABZ	Water	Metals GF/AA	05/12/82	13	1	1	15

Lot	Matrix	Analysis	Date Analyzed	Field Samples	QC Samples	Blanks	Total Samples
ACA	Water	Metals ICP	07/27/82	13	6	1	20
ACB	Leach	Anions	06/05/82	4	1	1	6
ACC	Leach	Semi Volatiles	07/14/82	4	1	1	6
ACD	Leach	5 Explosives	06/15/82	4	1	1	6
ACE	Leach	NG/PETN	06/17/82	4	1	1	6
ACF	Leach	Mercury	07/15/82	4	1	1	6
ACG	Water	Anions	06/25/82	5	2	1	8
ACH	Water	NG & PETN	06/29/82	5	2	1	8
ACI	Water	5 Explosives	07/01/82	5	2	1	8
ACJ	Water/Leach	Metals ICP	07/27/82	9	3	2	14
ACK	Water/Leach	Mercury	06/30/82	6	2	1	9
ACL	Water	Volatiles	07/02/82	7	2	1	10
ACM	Water	Cyanide	07/01/82	5	2	1	8
ACN	Water	Semi Volatiles	07/14/82	6	2	1	9
ACO	Water	Oil & Grease	07/01/82	5	1	1	7
ACP	Water/Leach	Metals GF/AA	07/07/82	9	2	2	13
ACQ	Water/Leach	Sodium	07/02/82	9	2	2	13
ACR	Water/Leach	Gross Alpha & Beta	06/18/82	47	3	7	57
ACS	Leach/Water	Gross Alpha & Beta	07/22/82	10	3	4	17

Table 3.
Summary of Lots by Analysis

Analysis	Lots
Volatiles (2J)	AAW, AAX, ABF, ABU, ACL
Semi Volatiles (3W)	AAE, AAQ, AAZ, ABI, ABT, ACC, ACN
5 Explosives (2B)	AAD, AAO, AAP, ABC, ABH, ABV, ACD, ACI
NG & PETN (6B)	AAC, AAM, AAN, ABB, ABG, ABW, ACE, ACH
Metals ICP (3T)	AAG, AAT, ABL, ACA, ACJ
Metals GF/AA (7T)	AAI, AAS, ABJ, ABZ, ACP
Mercury CV/AA (1D)	AAF, AAK, AAY, ABE, ABS, ACF, ACK
Sodium (1M)	AAJ, AAR, ABK, ABY, ACQ
Anions (2P)	AAA, AAB, AAH, AAL, AAU, AAV, ABA, ABD, ABO, ABP, ABQ, ACB, ACG
Cyanide (4K)	ABM, ABR, ACM
Oil & Grease (00)	ABN, ABX, ACO
Gross Alpha & Beta (30)	ACR, ACS

LABORATORY PROTOCOLS

This section contains the laboratory protocols used for the handling of samples and data from the Tooele Army Depot Survey. They are presented in the following order:

Sample Logging
Sample Lotting
Soil/Sediment Quartering Procedure
Soil Sample Handling And Wetting Volume Determination
Response to Out-Of-Control QC Data
Water Sample Containers
Soil Leach Sample Containers

Sample Logging

Soil Sample Log In

The soil samples will be received in styrofoam boxes packed with blue ice. As each soil sample is received it will be inspected and the following information entered into the first section of the sample logbook.

1. Date of arrival of sample at the laboratory.
2. The field identification numbers of the sample.
3. Sample matrix (soil, sediment).
4. Sampling date.
5. Date leaching procedure performed.
6. Analytical procedure to be run.
7. Observations concerning sample conditions (e.g. broken containers, leakage, lack of temperature control, etc.).

The soil samples will be stored in the walk-in refrigerator pending analysis. The blue ice must be removed before the samples are stored in the refrigerator.

Water Sample Log In

Each water sample will consist of several glass and plastic bottles packed in a styrofoam box with blue ice. Before storage of samples in the refrigerator the blue ice must be removed from the box. As each water sample is received it will be inspected and the following information entered into the first section of the sample logbook:

1. Date of arrival of sample at the laboratory.
2. The field identification numbers of the sample.
3. Sample matrix (surface water, ground water).
4. Sampling date.
5. Date split made.
6. Analytical procedure to be run.
7. Observation concerning sample conditions (e.g. broken containers, leakage, lack of temperature control, etc.).

In cases where samples are split (see below) the field identification number will be attached to each split container. The water samples will be stored in the walk-in refrigerator or in the sample room, as appropriate, grouped according to analytical procedure.

Water samples for explosives and metals will be split for analysis.

The water sample for explosives will be collected in a 1L amber glass bottle. The split will be made by pouring 250 mL directly from the 1L bottle into a 250 mL amber glass bottle. The sample remaining in the 1L bottle (approximately 750 mL) is to be analyzed for the five explosives: TNT, 2,4-DNT, 2,6-DNT, RDX and Tetryl. The sample in the 250 mL bottle is to be analyzed for NG and PETN. A preservative of 2-nitrodiphenylamine in isopropanol is added to each NG/PETN sample, resulting in a final concentration of 0.05 mM for the 2-nitrodiphenylamine.

The water sample for metals will be collected in a 1L plastic bottle. The splits will be made by pouring directly from the 1L bottle. The splits are as follows:

Split Container	Volume	Analytical Procedure
30 mL Plastic	30 mL	Metals-GF/AA
250 mL Plastic	250 mL	Mercury
30 mL Plastic	30 mL	Sodium
1L Plastic	remaining volume	Metals-ICP

Sample Lotting

Lot size is limited by storage time or the number of samples that can be processed through the method in one day.

When a particular lot is ready to analyze, the samples are removed from the storage area. The QC's are prepared in the same type of sample containers and randomly distributed among the samples. The three-letter, three-digit codes are tagged to the sample. The three letter, three-digit code for each sample is written on the field tag before the field tag is placed in the lot file folder. The following information is recorded for each sample in the second section of the logbook: Laboratory Number, Field (or QC) Number, Matrix, Analytical Procedure, Chemist, Date Analyzed.

Soil/Sediment Quartering Procedure

Each soil sample will be sieved through a 9.5 mm stainless steel sieve, if necessary. The sample will then be poured out on a double thickness of heavy duty aluminum foil (dull side up) and mixed with a stainless steel spatula. The sample will be quartered and opposite quarters returned to the sample bottle. The remaining pair of opposite quarters are combined, mixed and again quartered. Opposite quarters are returned to the sample bottle. This process is continued until approximately 200 g of soil is left. The sample is quartered and opposite quarters are combined, weighed and taken for extraction. The remaining pair of opposite quarters are combined, weighed and taken for the determination of wetting volume.

Each sediment sample will be poured through the 9.5 mm stainless steel sieve, if necessary. The sample will be stirred very well and an appropriate amount taken for leaching. The wetting volume is assumed to be zero. Therefore, no wetting volume determination will be performed for sediment.

Soil Sample Handling And Wetting Volume Determination

Break down soil lumps. Do not grind, just break down to natural size particles. Screen through the 9.5 mm screen. Weigh and discard what was retained on the sieve. Weigh what went through the sieve.

Perform the necessary splits to obtain approximately 100 g for extraction and approximately 100 g for determination of wetting volume. In the event that a very small sample is received as little as 25 to 50 grams can be used to determine the wetting volume.

The wetting volume is determined as follows:

1. Weigh approximately 100 g of soil into a 250 mL plastic centrifuge bottle. Add a measured volume of water - 100 mL for 100 g.
2. Cap and shake well. Allow to stand for at least one hour.
3. Centrifuge.
4. Decant the supernatant water and measure its volume with a graduated cylinder.
5. Determine the wetting volume by subtraction:

Wetting Volume = (Original Volume of Water) - (Volume of Supernatant)

The wetting volume is used to determine the total leaching volume.

Response To Out-of-Control QC Data

All analytical data should be reduced as soon as possible and routed to the quality assurance specialist (QAS).

In the event that the data is out of control, analyses will be discontinued until the analytical system is demonstrated to be under control. All data obtained since analysis of the latest in-control QC samples will be considered invalid. Efforts will be directed toward the determination of the cause of the problem(s) and required corrective actions will be implemented to reinstate a reliable analytical system. Once problems are identified and corrected, data considered to be invalid will be evaluated. If identified errors can be corrected without the reanalysis of the samples (as, for example, in the case of calculation errors or improper processing of reliable raw analytical data), corrections will be effected without additional analytical work. All samples for which reanalysis is the only reasonable corrective measure, will be reanalyzed by UBTL if sufficient sample is available and if the integrity of the remaining portion of the sample is intact. Resampling and reanalysis will be required to correct out-of-control results if the conditions noted in the preceding cannot be satisfied.

As noted, the UBTL QAS will carefully monitor (on a real-time basis) the results of the control samples employed for this contract work, and in the event that a QC result is out-of-control, specific steps will be implemented to identify and correct the deficiency. The steps, to be pursued jointly by the analyst and the QAS, are as follows:

1. Check all data processing procedures and calculations.
2. Check blank samples for identification of possible interferences or other problems.
3. Check instrumentation performance (if applicable) by observing the response of the instrument while processing a sample material for which the expected response is known. Operating conditions must be similar to those used for analysis of the samples under consideration.
4. Check the original standard preparation procedures by preparing new standards, obtaining a new standard calibration curve from the new data, and comparing the new standard curve with the original standard calibration curve.
5. Check the integrity of the original QC samples by preparing new QC samples following the same procedures, and analyzing the new QC samples.

6. Carefully review raw data (e.g., recorder output, chromatograms, computer output) in an effort to identify interferences, unusual signals (unusual peak shapes, etc), or other factors which could produce inaccuracies.
7. Reanalyze the samples with new standards and new QC samples if sufficient field sample material is available. The entire analytical process including, for example, extractions, digestions, etc. should be repeated.
8. Any other special procedures required to address recalcitrant problems not solved by the preceding steps.

Water Sample Containers

Table 4 lists the containers to be used in the collection and analysis of water samples from the Tooele Army Depot Survey.

Table 4.
Water Sample Containers

Methods	Sampling Container		Split Container		Volume to Analyst	Volume for Analysis
	Size	Material	Size	Material		
Volatiles (624)	2 x 40 mL	Amber Glass	-	-	2 x 40 mL	2 x 5 mL
Semi-Volatiles (625)	1L	Amber Glass	-	-	1L	1L
Explosives	1L	Amber Glass	1L	Amber Glass	750 mL	500 mL
NG & PETN			250 mL	Amber Glass	250 mL	100 mL
Oil & Grease	1L	Amber Glass	-	-	1L	1L
Metals-ICP	1L	Plastic	1L	Plastic	690 mL	250 mL
Metals - GF/AA			30 mL	Plastic	30 mL	20 mL
Mercury - CV/AA			250 mL	Plastic	250 mL	100 mL
Sodium - AA			30 mL	Plastic	30 mL	20 mL
Anions - IC	30 mL	Plastic	-	-	30 mL	5 mL
Cyanide	1L	Plastic	-	-	1L	500 mL
Gross Alpha & Beta	500 mL	Plastic	-	-	500 mL	250 mL

Soil Leach Sample Containers

Table 5 lists the containers to be used in the collection and analysis of soil leach samples from the Tooele Army Depot Survey.

Table 5.
Soil Leach Sample Containers

Method	Leach Container		Volume to Analyst	Volume for Analysis
	Size	Material		
Volatiles (624)	-	-	-	-
Semi-Volatiles (625)	250 mL	Amber Glass	200 mL	200 mL
Explosives	250 mL	Amber Glass	100 mL	100 mL
NG & PETN	40 mL	Amber Glass	40 mL	20 mL
Oil & Grease	-	-	-	-
Metals-ICP	250 mL	Plastic	50 mL	50 mL
Metals - GF/AA	30 mL	Plastic	30 mL	20 mL
Mercury - CV/AA	30 mL	Plastic	30 mL	20 mL
Sodium - AA	30 mL	Plastic	30 mL	20 mL
Anions - IC	30 mL	Plastic	30 mL	20 mL
Cyanide	-	-	-	-
Gross Alpha & Beta	250 mL	Plastic	125 mL	50 mL

Remainder is stored as follows: 1) One amber glass 250 mL bottle filled to top; 2) The rest in a 250 mL plastic bottle, preserved with nitric acid.

ANALYTICAL METHODS

Qualitative Analysis Methods

For the screening part of the Tooele Army Depot Survey, twelve laboratory analyses were performed. Eleven analyses were certified at the qualitative level. The analysis for oil and grease was performed without certification. Table 6 summarizes the results of the qualitative analysis certifications. The soil leach samples were analyzed by the same method used for water samples with adjustments made for sample size and detection limit as suggested in the Solid Waste Leaching Procedure (SWLP).

Semi-Quantitative Analysis Methods

At the request of Ertec Western, Inc., UBTL proceeded with the recertification of the analytical methods at the semi-quantitative level. It was the intent of the Project Officer, Mr. Donald Campbell, that no resampling be performed and that the semi-quantitative recertification be applied to the data already reported by the laboratory.

UBTL reviewed the analytical data and recommended that the methods for NG & PETN (6B) and mercury (1D) not be recertified because none of the field samples contained those analytes at or above the detection limit.

When the qualitative analysis certifications were being performed, the UBTL chemists were directed by the Chemical Analysis Program Manager, Dr. Sim D. Lessley, to analyze six samples at the levels required for the semi-quantitative recertification, if time permitted. This was done with a view to reducing recertification costs for the resampling portion of the program. Upon careful review of the original certification data, it was discovered that the UBTL chemists had been able to run the six levels necessary for the semi-quantitative certification of several methods while the qualitative analyses were being certified. These methods were:

Method 2J (Volatiles in water by HP-5985B GC/MS)
Method 7T (Zinc, Arsenic and Nickel in water by GF/AA)
Method 1M (Sodium in water by AA)

Table 6.
Certification of Qualitative Analyses

Method	Method #	Analyte	Analyte Code	µg/L LOD Water	µg/L LOD Soil Leach	Slope (recovery) JMR	Slope (recovery) RWW
Volatiles (624)	2J	Benzene	C6H6	1	-	1.27	1.22
		Bromomethane	CH3BR	1	-	1.16	0.367
		Chlorobenzene	CLC6H5	1	-	1.03	1.39
		1,2-Dichloroethane	12DCLE	1	-	1.24	0.767
		Trans-1,2-Dichloroethene	T12DCE	1	-	1.24	0.903
		1,1,2,2-Tetrachloroethane	TCLEA	1	-	1.42	1.01
		1,1,1-Trichloroethane	111TCE	1	-	1.41	0.931
		Trichloroethene	TRCLE	1	-	1.28	1.45
						JMR	RWW
Semi-Volatiles	3W	Hexachloroethane	CL6ET	20	100	0.333	0.592
		Naphthalene	NAP	2	10	0.530	0.76
		Nitrobenzene	NB	8	40	0.516	0.80
		3,5-Dinitroaniline	35DNA	20	100	1.19	0.559
		2-Amino-4,6-DNT	2A46DT	20	100	1.38	1.46
		Fluoranthene	FANT	2	10	1.01	1.00
		3-Nitrotoluene	3NT	10	50	0.792	1.00
		Diethylphthalate	DEP	2	10	1.04	0.99
		Alpha-BHC	ABHC	20	100	0.983	1.00
		p,p'-DDT	PPDDT	2	10	1.07	1.00
		Dieldrin	DLDRN	2	10	1.04	0.70
		Lindane	LIN	20	100	1.03	1.02
		Heptachlor	HPCL	8	40	0.998	0.76
		Aroclor-1016	PCB016	70	350	0.925	1.00
		Aroclor-1262	PCB262	100	500	0.991	0.73
		2,4-Dimethylphenol	24DMPN	20	100	0.028	0.60
		2,4-Dinitrophenol	24DNP	30	150	1.02	1.07
		2-Methyl-4,6-dinitrophenol	46DN2C	20	100	1.27	1.08
		Pentachlorophenol	PCP	20	100	1.14	1.02
		Phenol (D6)	PHEND6	3	15	0.235	0.252

Table 6.
Certification of Qualitative Analyses (Continued)

Method	Method #	Analyte	Analyte Code	µg/L LOD Water	µg/L LOD Soil Leach	Slope (recovery)	
Explosives	2B	2,4-DNT	24DNT	2	10	0.739	
		2,6-DNT	26DNT	3	15	0.741	
		2,4,6-TNT	246TNT	2	10	0.852	
		Tetryl	TETRYL	1	5	0.897	
		RDX	RDX	1	5	0.940	
NG & PETN	6B	Nitroglycerine	NG	20	100	0.643	
		PETN	PETN	5	25	1.08	
Metals-ICP	3T	Arsenic	AS	60	300	0.973	
		Beryllium	BE	0.5	3	1.06	
		Cadmium	CD	6	30	0.964	
		Chromium	CR	5	25	0.967	
		Copper	CU	6	30	1.07	
		Lead	PB	30	150	0.928	
		Nickel	NI	20	100	0.931	
		Silver	AG	8	40	0.929	
		Zinc	ZN	20	100	0.832	
Metals-GF/AA	7T	Arsenic	AS	7	7	0.913	
		Nickel	NI	5	5	0.94	
		Zinc	ZN	1	1	1.11	
						CLM	DWB
Mercury-CV/AA	1D	Mercury	HG	0.2	1	0.915	0.909
Sodium	1M	Sodium	NA	1000	1000	0.989	

Table 6.
Certification of Qualitative Analyses (Continued)

Method	Method #	Analyte	Analyte Code	µg/L LOD Water	µg/L LOD Soil Leach	Slope (recovery) LJD	Slope (recovery) REB
Anions	2P	Chloride	CL	1000	1000	0.971	1.15
		Fluoride	F	1000	1000	0.894	1.15
		Nitrate	NO3	1000	1000	1.14	1.06
		Nitrite	NO2	1000	1000	1.05	0.956
		Phosphate	PO4	1000	1000	0.938	1.01
		Sulfate	SO4	1000	1000	0.934	1.03
Cyanide	4K	Cyanide	CYN	10	-	0.919	
Oil & Grease	00	Oil & Grease	OILGR	5000	-	-	
Gross Alpha &	30	Gross Alpha	ALPGL	2pCi/L	10pCi/L	0.893	
Beta	30	Gross Beta	BETGL	3pCi/L	15pCi/L	0.786	

Method 2P (Anions in water by Ion Chromatography)
Method 4K (Cyanide in water by Spectrophotometry)
Method 3T (Nine metals in water by ICP)

The necessary analytical work was performed to recertify the three remaining analytical methods:

Method 3W (Semi-volatiles in water by HP 5985B GC/MS)
Method 2B (Five Explosives in water by HPLC)
Method 30 (Gross Alpha and Beta Radiation in water)

Table 7 summarizes the results of semi-quantitative analysis certifications. Note that the last column of the table contains a multiplier (certified slope divided by recertified slope) for use in converting qualitative analysis data to semi-quantitative analysis data.

The semi-quantitative analytical methods are contained in Appendix F.

Table ..
Certification of Semi-Quantitative Analyses

Method	Method #	Analyte	Analyte Code	Cert. LOD µg/L Water	Cert. Slope	Recert. LOD µg/L Water*	Recert. LOD µg/L Leach	Recert. Slope	Cert. Slope / Recert. Slope
					(JMR)				
Volatiles (624)	2J	Benzene	C6H6	1	1.27	2	--	0.988	1.29
		Bromomethane	CH3BR	1	1.16	5	--	0.943	1.23
		Chlorobenzene	CLC6H5	1	1.03	2	--	1.08	0.954
		1,2-Dichloroethane	12DCLE	1	1.24	2	--	1.16	1.07
		Trans-1,2-Dichloroethene	T12DCE	1	1.24	2	--	1.03	1.20
		1,1,2,2-Tetrachloroethane	TCLEA	1	1.42	2	--	1.01	1.41
		1,1,1-Trichloroethane	111TCE	1	1.41	3	--	1.25	1.13
		Trichloroethene	TRCLE	1	1.28	3	--	1.18	1.08
					(RWW)				
Semi-Volatiles (625)	3W	Hexachloroethane	CL6ET	20	0.592	8(20)	100	0.791	0.748
		Naphthalene	NAP	2	0.76	2	10	0.999	0.761
		Nitrobenzene	NB	8	0.80	5(8)	40	0.987	0.811
		3,5-Dinitroaniline	35DNA	20	0.559	20	100	0.842	0.664
		2-Amino-4,6-DNT	2A46DT	20	1.46	20	100	0.983	1.49
		Fluoranthene	FANT	2	1.00	3	15	0.777	1.30
		3-Nitrotoluene	3NT	10	1.00	6(10)	50	0.960	1.04
		Diethylphthalate	DEP	2	0.99	5	25	1.13	0.876

*The value given is the detection limit for which the method was certified. The value in parentheses is the detection limit to be used for the Tooele Survey.

Tab. .
Certification of Semi-Quantitative Analyses (Continued)

Method	Method #	Analyte	Analyte Code	Cert. LOD µg/L Water	Cert. Slope	Recert. LOD µg/L Water*	Recert. LOD µg/L Leach	Recert. Slope	Cert. Slope / Recert. Slope
		Alpha-BHC	ABHC	20	1.00	30	150	1.12	0.893
		p,p'-DDT	PPDDT	2	1.00	2	10	0.782	1.37
		Dieldrin	DLDRN	2	0.70	4	20	1.01	0.693
		Lindane	LIN	20	1.02	30	150	0.471	2.17
		Heptachlor	HPCL	8	0.76	9	45	0.642	1.18
		Aroclor-1016	PCB016	70	1.00	300	1500	0.926	1.08
		Aroclor-1262	PCB262	100	0.73	300	1500	0.798	0.915
		2,4-Dimethylphenol	24DMPN	20	0.60	20	100	0.048	12.5
		2,4-Dinitrophenol	24DNP	30	1.07	40	200	0.803	1.33
		2-Methyl-4,6-dinitrophenol	46DN2C	20	1.08	40	200	0.880	1.23
		Pentachlorophenol	PCP	20	1.02	40	200	0.612	1.67
		Phenol (D6)	PHEND6	3	0.252	6	30	0.340	0.741
Explosives	2B	2,4-DNT	24DNT	2	0.739				
		2,6-DNT	26DNT	3	0.741				
		2,4,6-TNT	246TNT	2	0.852				
		Tetryl	TETRYL	1	0.897				
		RDX	RDX	1	0.940				
NG & PETN	6B	Nitroglycerine	NG	20	0.643	--	--	--	--
		PETN	PETN	5	1.08	--	--	--	--

*The value given is the detection limit for which the method was certified. The value in parentheses is the detection limit to be used for the Tooele Survey.

Table 7.
Certification of Semi-Quantitative Analyses (Continued)

Method	Method #	Analyte	Analyte Code	Cert. LOD µg/L Water	Cert. Slope	Recert. LOD µg/L Water*	Recert. LOD µg/L Leach	Recert. Slope	Cert. Slope / Recert. Slope
Metals-ICP	3T	Arsenic	AS	60	0.973	40(60)	300	0.958	1.02
		Beryllium	BE	0.5	1.06	0.3(0.5)	3	0.988	1.07
		Cadmium	CD	6	0.964	6	30	0.894	1.08
		Chromium	CR	5	0.967	4(5)	25	0.927	1.04
		Copper	CU	6	1.07	6	30	0.989	1.08
		Lead	PB	30	0.928	20(30)	150	0.888	1.05
		Nickel	NI	20	0.931	7(20)	100	0.893	1.04
		Silver	AG	8	0.929	8	40	0.832	1.12
		Zinc	ZN	20	0.832	6(20)	100	0.814	1.02
Metals-GF/AA	7T	Arsenic	AS	7	0.913	4(7)	7	0.945	0.966
		Nickel	NI	5	0.94	4(5)	5	1.01	0.931
		Zinc	ZN	1	1.11	3	3	1.25	0.888
Mercury-CV/AA	1D	Mercury	HG	0.2	0.915	0.1(0.2)	1	0.903	1.01
Sodium	1M	Sodium	NA	1000	0.989	1000	1000	1.00	0.989
Anions	2P	Chloride	CL	1000	0.971	1000	1000	0.990	0.981
		Fluoride	F	1000	0.894	2000	2000	1.01	0.885
		Nitrate	NO3	1000	1.14	2000	2000	1.03	1.11

*The value given is the detection limit for which the method was certified. The value in parentheses is the detection limit to be used for the Tooele Survey.

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Table 7.
Certification of Semi-Quantitative Analyses (Continued)

Method	Method #	Analyte	Analyte Code	Cert. LOD µg/L Water	Cert. Slope	Recert. LOD µg/L Water*	Recert. LOD µg/L Leach	Recert. Slope	Cert. Slope / Recert. Slope
		Nitrite	NO2	1000	1.05	1000	1000	0.972	1.08
		Phosphate	PO4	1000	0.938	1000	1000	1.02	0.920
		Sulfate	SO4	1000	0.934	2000	2000	0.961	0.972
Cyanide	4K	Cyanide	CYN	10	0.919	5(10)	--	0.942	0.976
Oil & Grease	00	Oil & Grease	OILGR	5000	--	--	--	--	--
Gross Alpha &	30	Gross Alpha	ALPGL	2 pCi/L	0.893				
Beta	30	Gross Beta	BETGL	3 pCi/L	0.786				

*The value given is the detection limit for which the method was certified. The value in parentheses is the detection limit to be used for the Tooele Survey.

QUALITY CONTROL

Quality Control Samples

Quality control samples were included in each analysis lot. The types of samples prepared by the UBTL Quality Assurance Specialist were:

Standard Water Spike - the analytes of interest were made up at the certified detection limit in standard water (standard water is defined in the USATHAMA QA/QC Manual).

Natural Water Spike - a field sample was split and the analytes of interest were made up at the detection limit in one of the splits.

Field Spike - a standard water spike was prepared, as described above, transported to the field and returned to the laboratory for analysis.

Standard Water Blank - a sample of the standard water used to prepare the standard water spikes was included as a blank.

Field Blank - a standard water blank was prepared as described above, transported to the field and returned to the laboratory for analysis.

The radiological samples represented an exception to the foregoing. In the case of gross alpha and gross beta determinations the contract laboratory, Controls for Environmental Pollution (CEP), prepared quality control samples and method blanks for each analysis lot.

Tables 8 and 9 summarize the quality control objectives for water samples and soil leach samples, respectively. In some cases there were departures from the objectives. These cases are noted individually in the lot quality control report (see below).

Table 8.
Quality Control Objectives for Water Samples

Method	Std. H_2O Blank	Std. H_2O Spike	Natural Spike	Field Blank	Field Spike
Volatiles (624)	one				
Bromomethane Chlorobenzene 1,2-Dichloroethane		one	none	one	one lot
Semi-Volatiles (625)	one				
Hexachloroethane 3,5-Dinitroaniline Dieldrin 2,4-Dinitrophenol		one	one	one	one lot
Explosives	one				
All analytes		one	one	one	one lot
NG & PETN	one				
Both analytes		one	one	one	one lot
Metals - ICP	one				
All except silver		one	one	one	one lot
Silver		one	none	one	one lot
Metals - GF/AA	one				
All analytes		one	one	one	one lot
Mercury - CV/AA	one	one	one	one	one lot
Sodium	one	one	one	one	one lot
Anions	one				
All analytes		one	one	one	one lot
Cyanide	one	one	one	one	one lot
Oil & Grease	one	none	none	one	none
Gross Alpha & Beta	one	none	none	one	none

Table 9.
Quality Control Objectives for Soil Leach Samples

Method	Std. H_2O Blank	Std. H_2O Spike
Volatiles (624)	none	
Bromomethane		
Chlorobenzene		none
1,2-Dichloroethane		
Semi-Volatiles (625)	one	
Hexachloroethane		
3,5-Dinitroaniline		one
Dieldrin		
2,4-Dinitrophenol		
Explosives	one	
All analytes		one
NG & PETN	one	
Both analytes		one
Metals - ICP	one	
All except silver		one
Silver		one
Metals - GF/AA	one	
All analytes		one
Mercury - CV/AA	one	one
Sodium	one	one
Anions	one	
All analytes		one
Cyanide	one	one
Oil & Grease	one	none
Gross Alpha & Beta	one	none

Quality Control Reports

At the request of Dr. Les Eng, Mr. Lance M. Eggenberger, (the UBTL Quality Assurance Specialist) prepared a quality control report for each lot of samples. In each report the results of the analysis of the quality control samples for the lot were presented and discussed. Copies of all of the quality control reports for the Tooele Army Depot Survey are included in Appendix G.

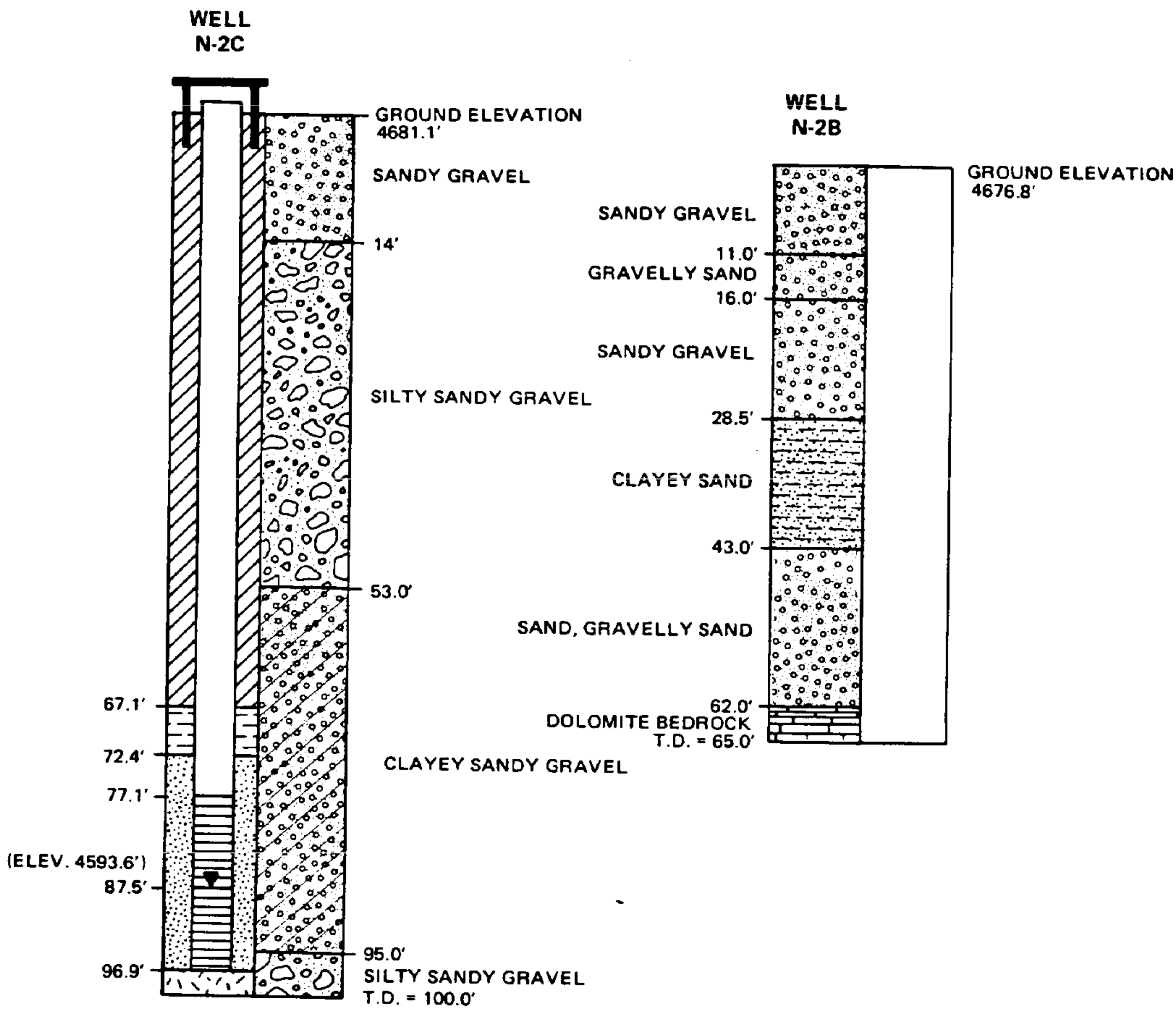
Quality Control Results

Also at the request of Dr. Les Eng the UBTL Quality Assurance Specialist tabulated the results of the analyses of all quality control samples by analyte. Those tabulations are presented in Appendix H. The quality control results are summarized by lot with the range of the field sample data for each lot in Appendix I.

Appendix C

Well Construction and

Lithology Summaries



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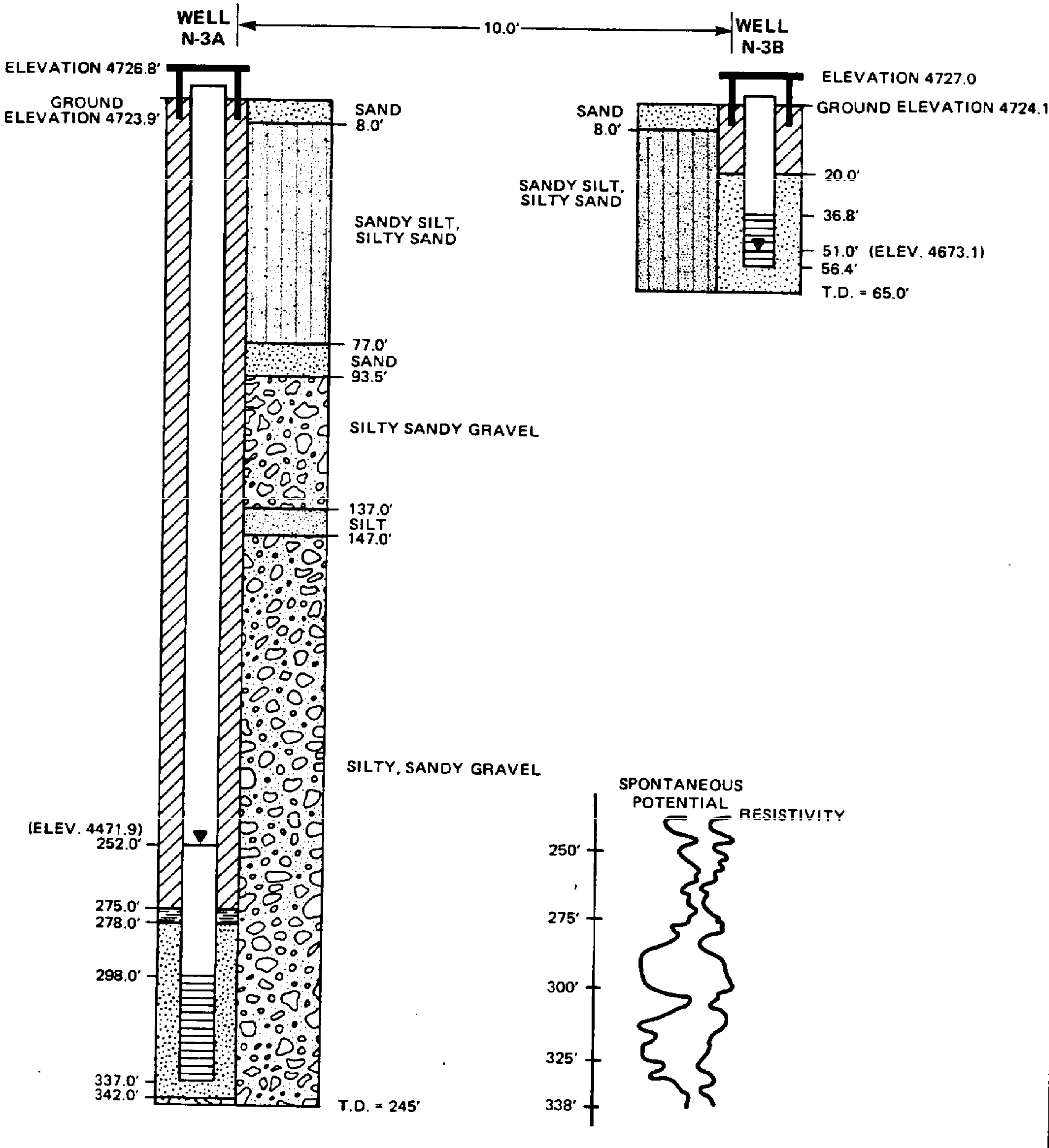
LITHOLOGY AND WELL DESIGN
WELLS N-2C AND N-2B

6-82



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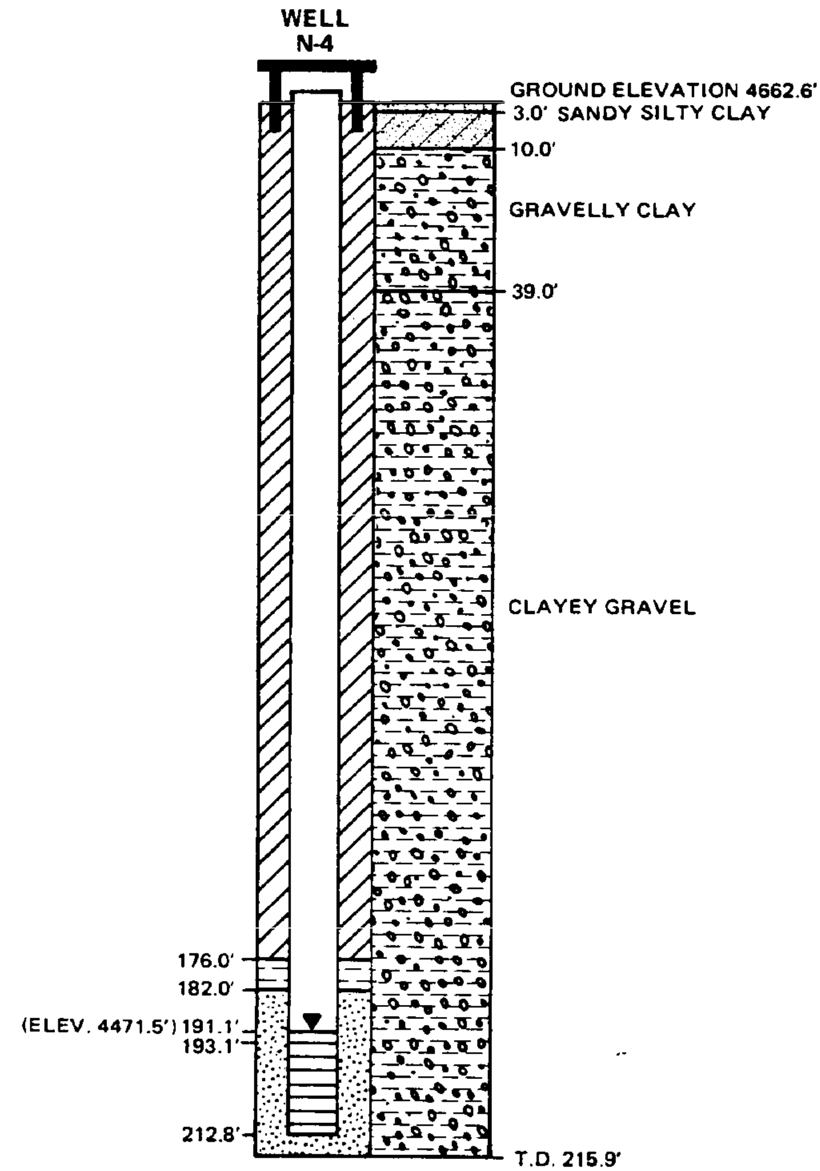
TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
WELLS N-3A AND N-3B

6-82



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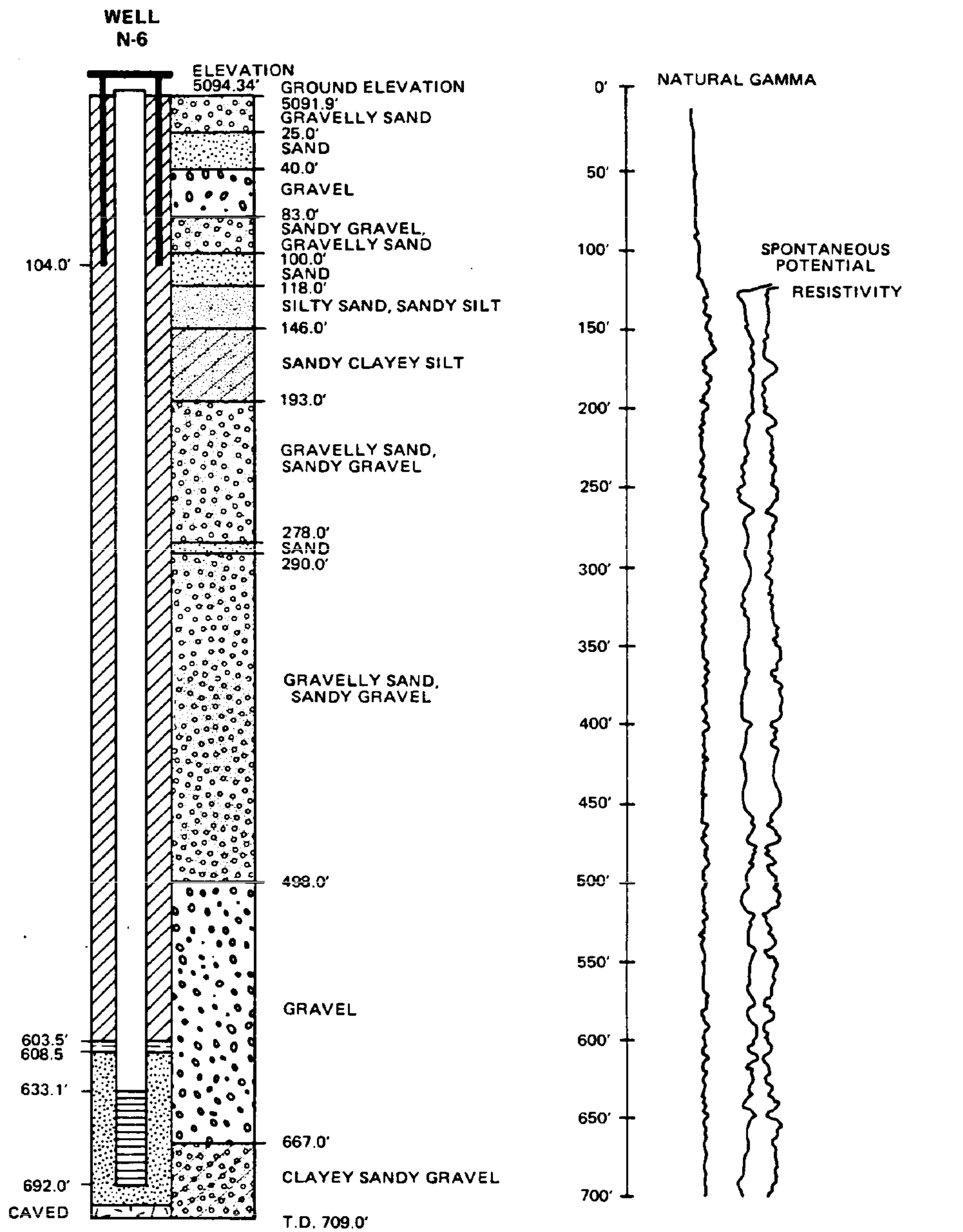
LITHOLOGY AND WELL DESIGN
WELL N-4

6-82



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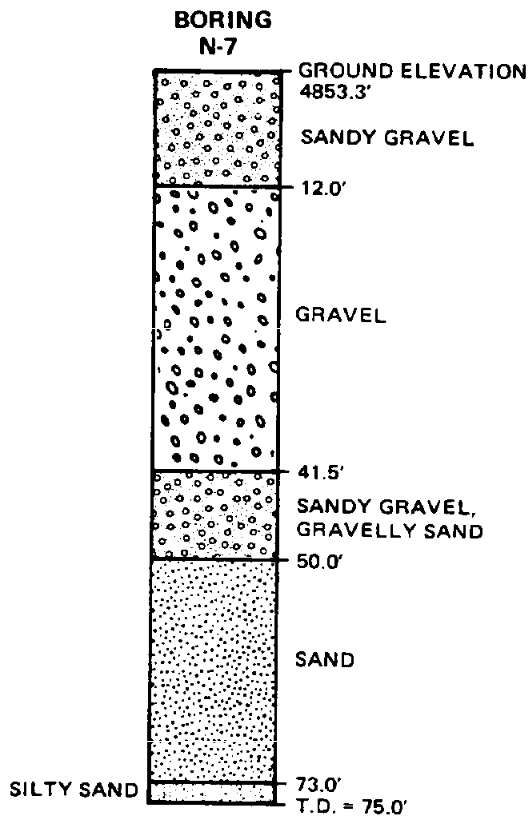
LITHOLOGY AND WELL DESIGN
WELL N-6

6-82



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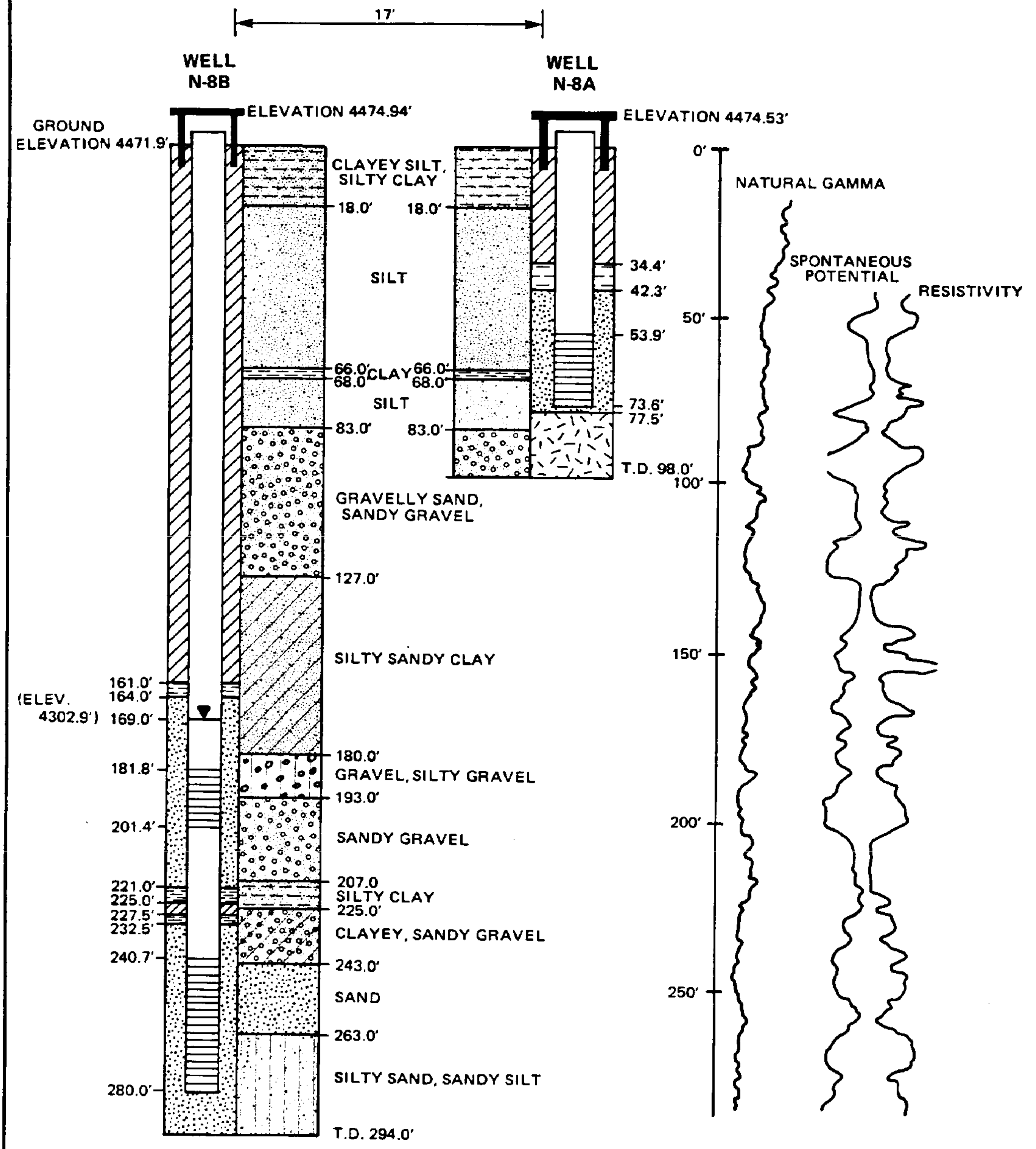
TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
BORING N-7

6-82



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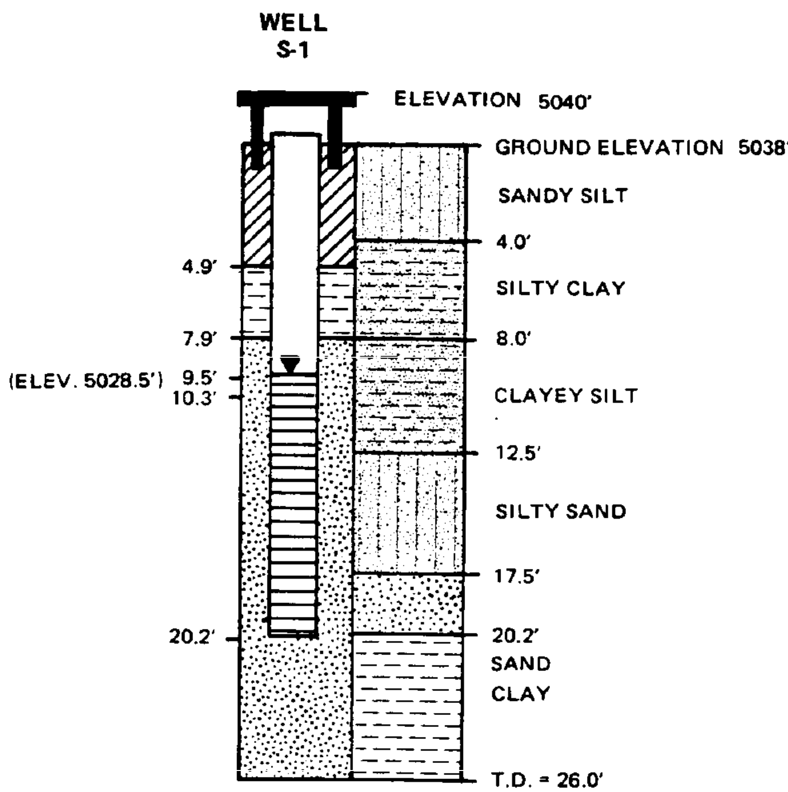
TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
WELLS N-8A AND N-8B

6-82



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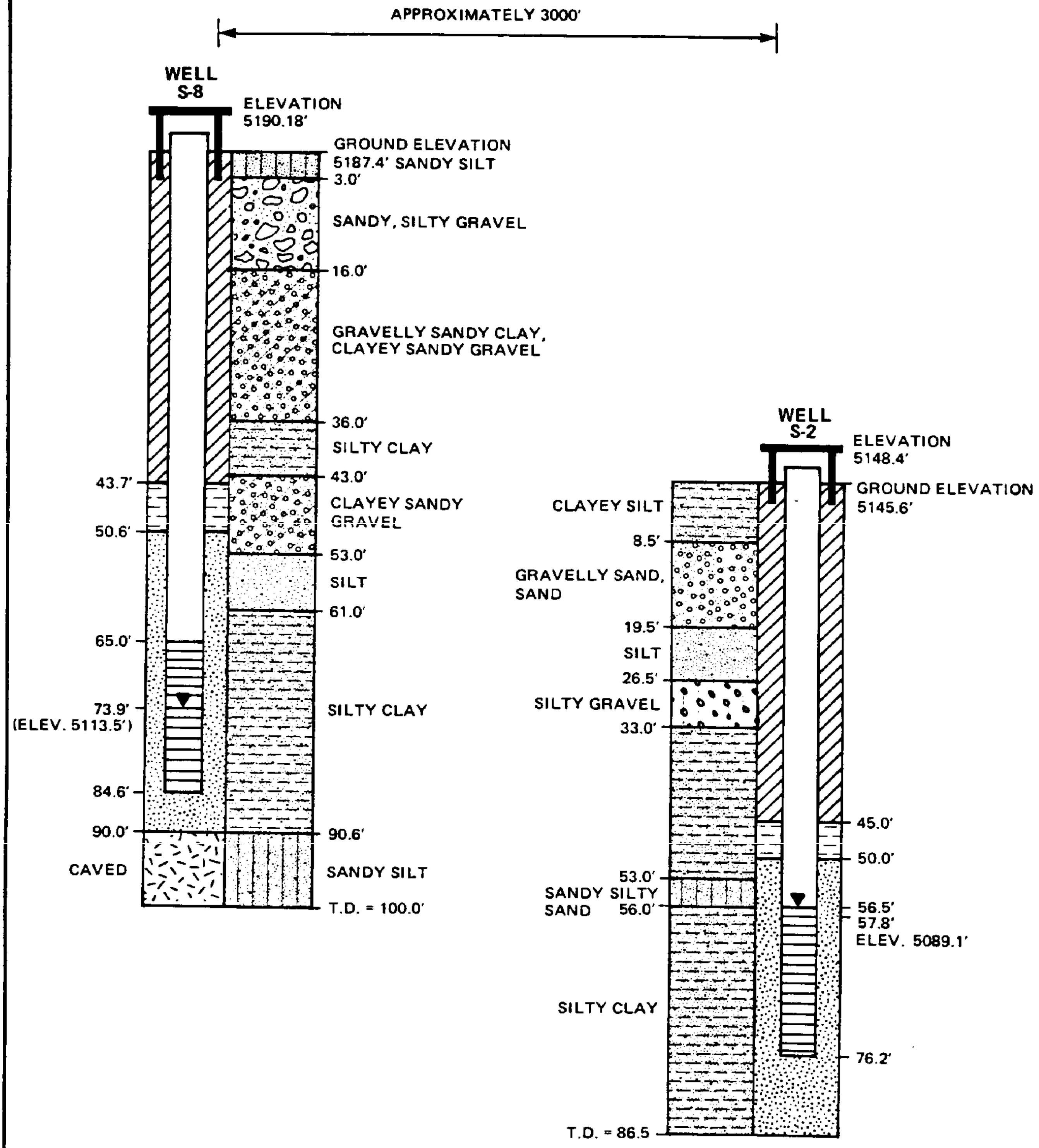
TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
WELL S-1

6-82



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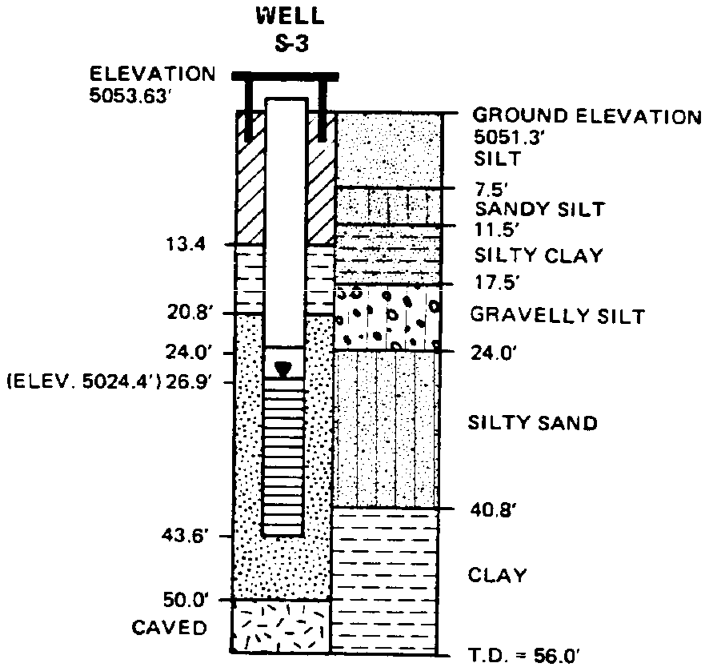
TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
WELLS S-2 AND S-8

6-82



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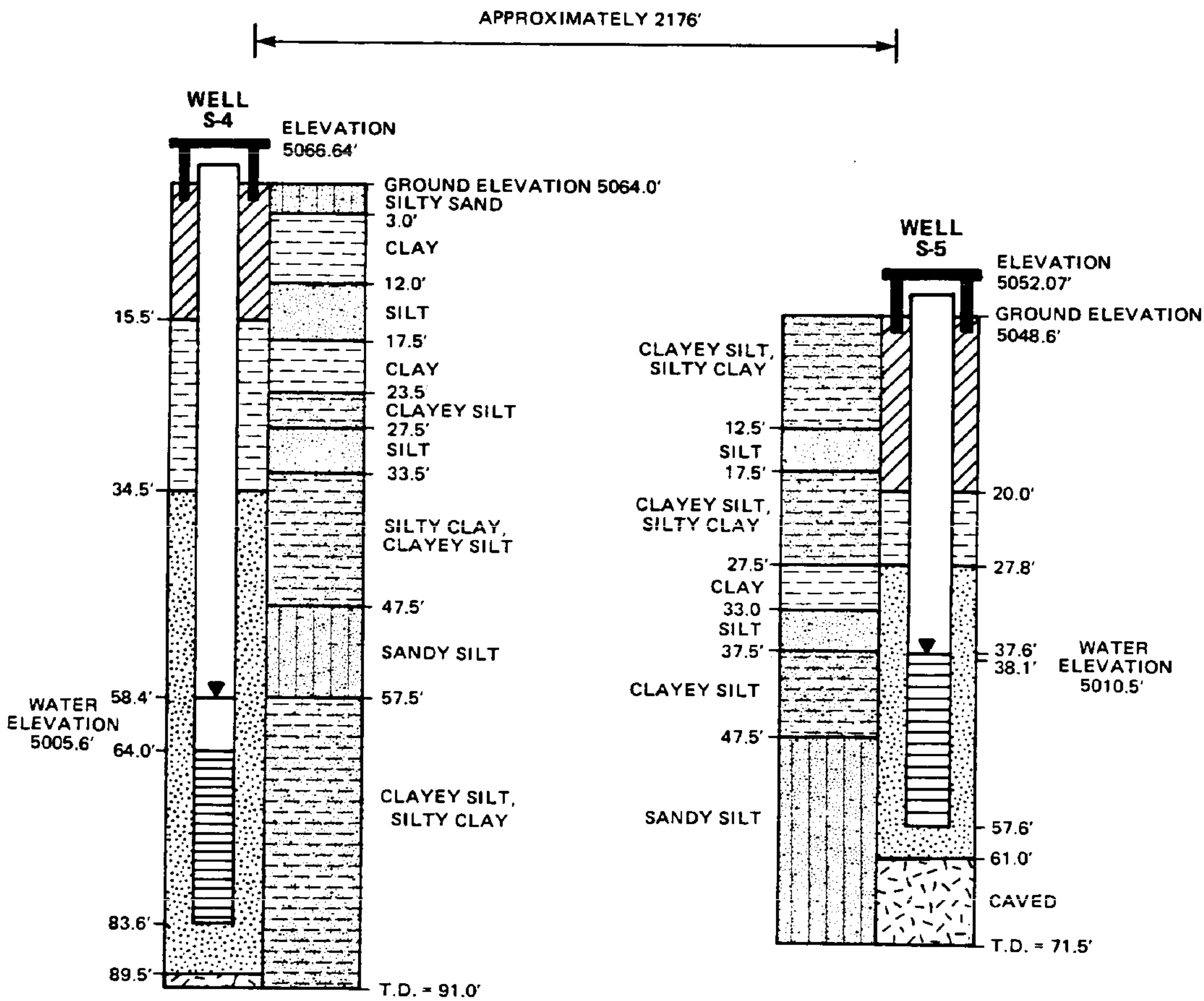
	TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
WELL S-3

6-82



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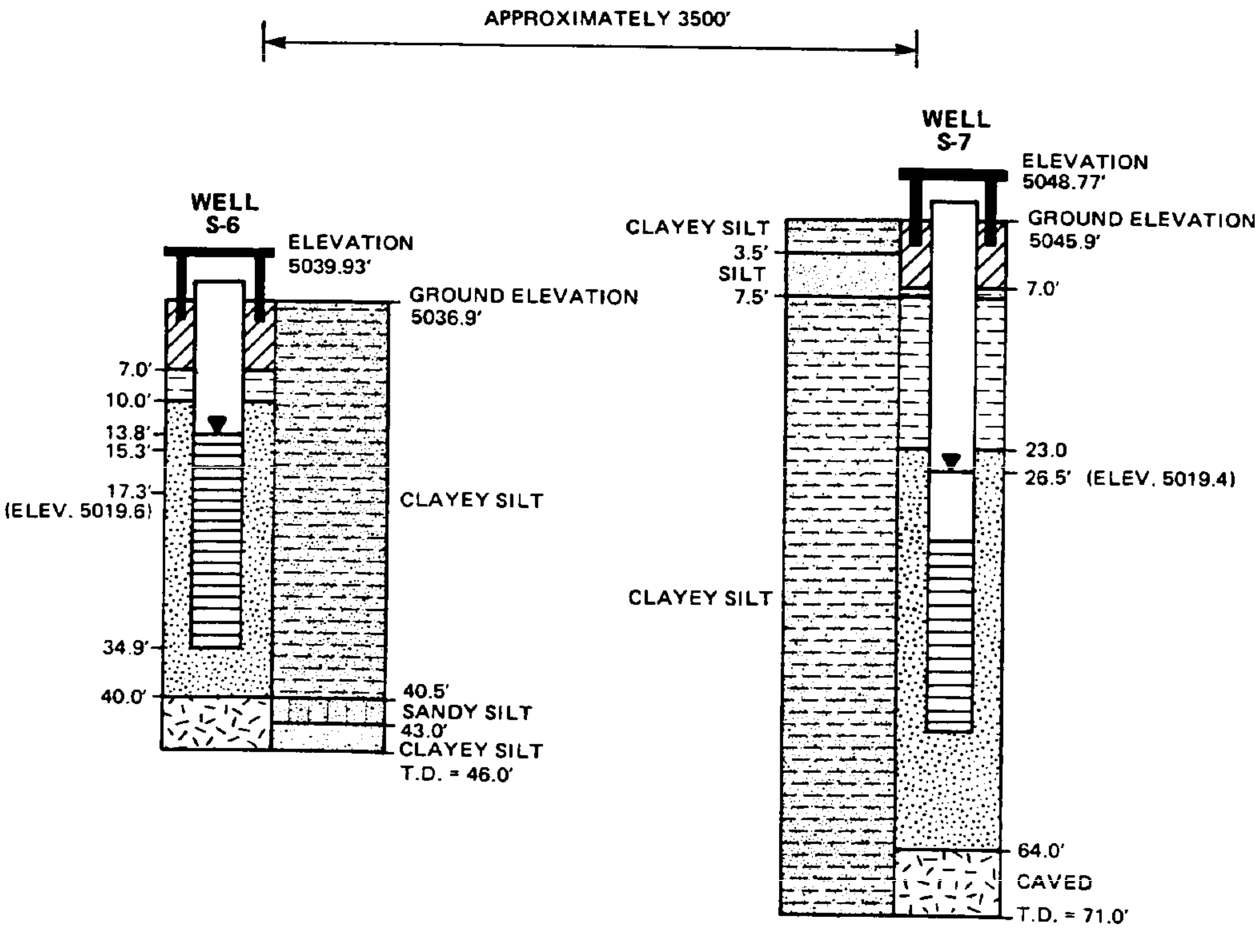
TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
WELLS S-4 AND S-5

6-82



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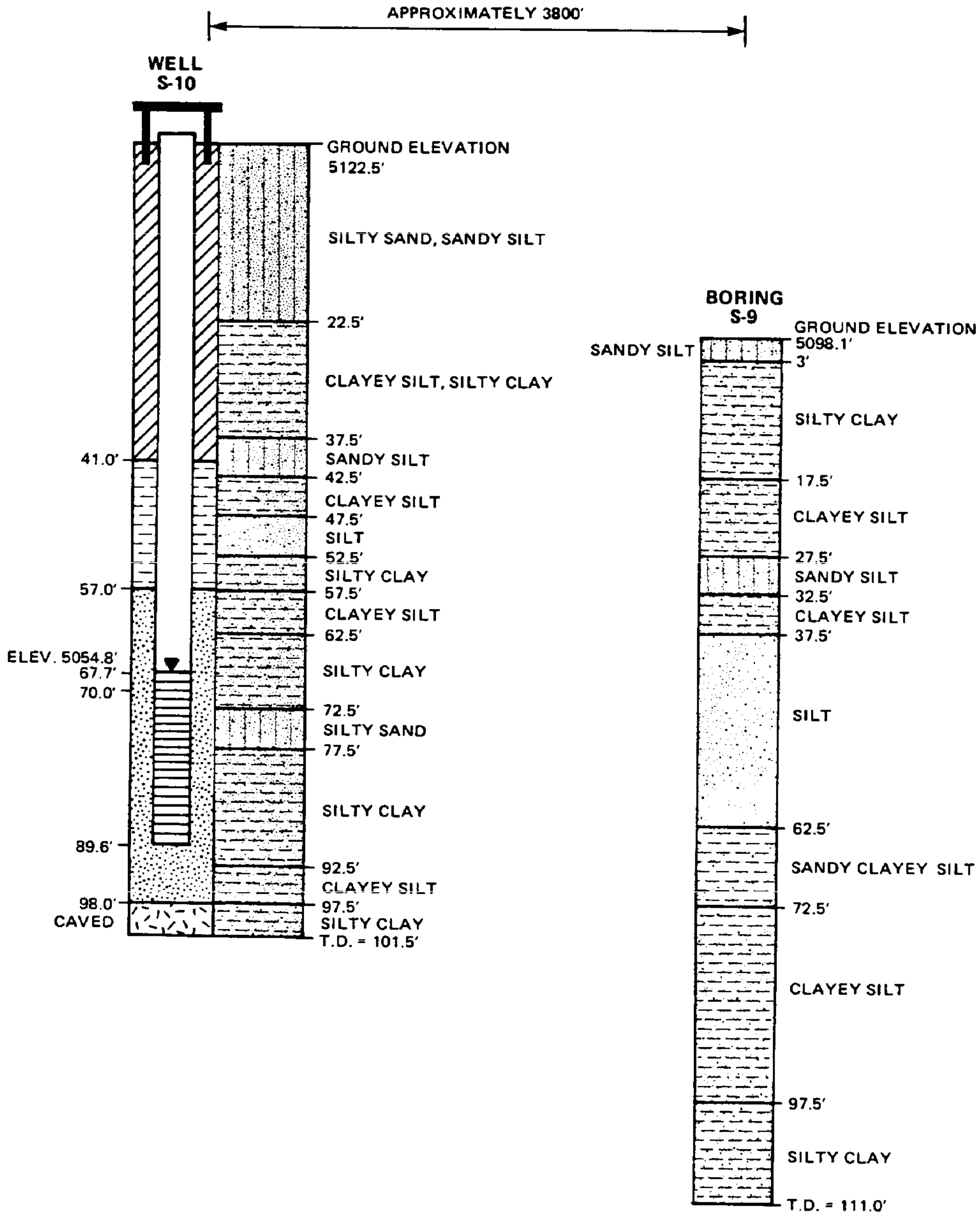
TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
WELLS S-6 AND S-7

6-82



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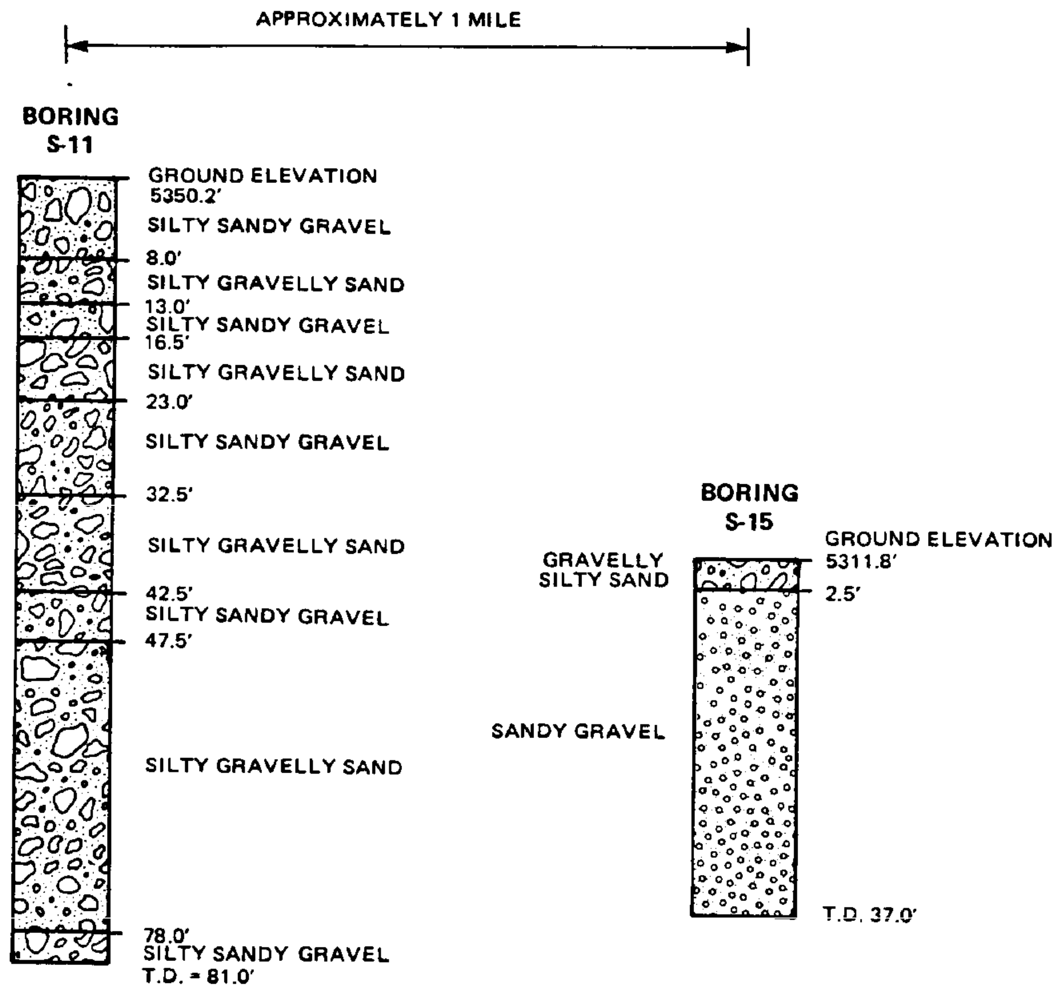
TOOELE ARMY DEPOT	

LITHOLOGY AND WELL DESIGN
WELL S-10 AND BORING S-9

6-82



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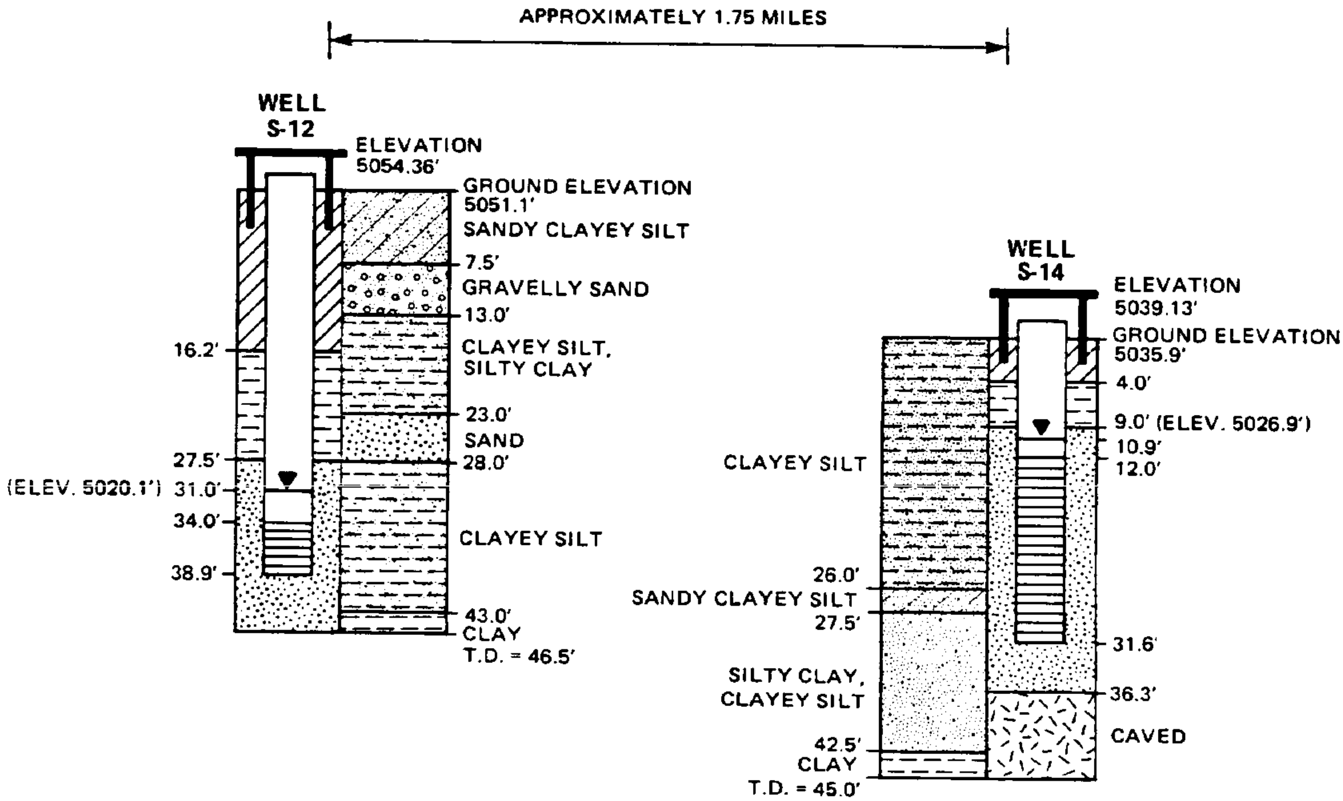
TOOELE ARMY DEPOT

LITHOLOGY AND WELL DESIGN
BORINGS S-11 AND S-15

6-82



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LITHOLOGY AND WELL DESIGN
WELLS S-12 AND S-14

6-82

Appendix D

Geophysics Program

D-1 Magnetic Surveys

D-1.1 Introduction

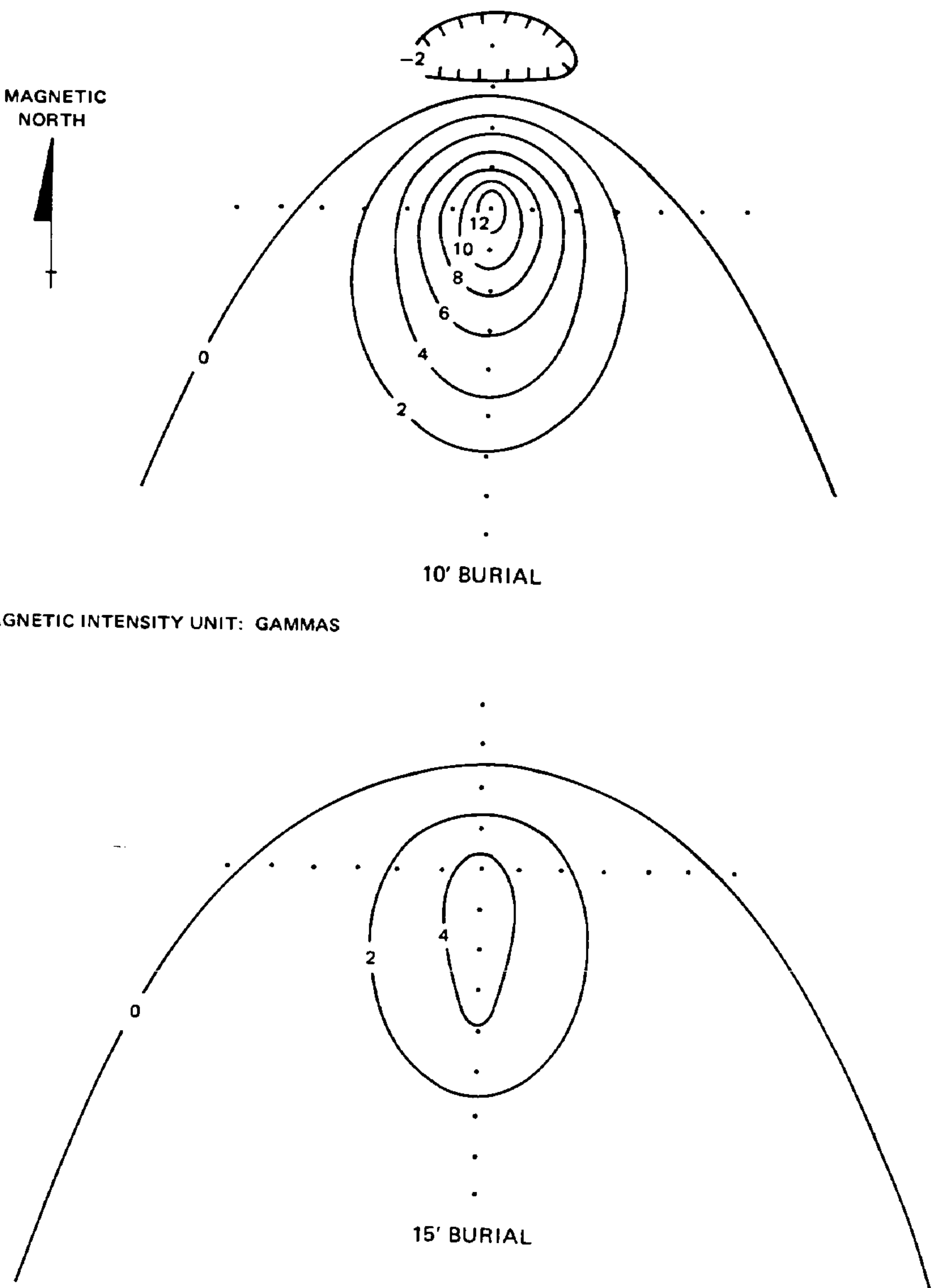
Ground magnetic surveys were performed at three potential drilling sites in the North Area of TEAD and four sites in the South Area for the purpose of detecting buried metallic objects, which might pose a hazard to personnel involved in drilling.

The surveys were designed to detect unexploded ordnance or objects equivalent to a 55-gallon steel drum buried as deeply as 15 feet. The theoretical magnetic anomaly produced by such an object is shown in Figure 1 - a computer simulation for depths of burial of 10 and 15 feet. The simulation assumes that the anomaly is produced solely by magnetization induced by the geomagnetic field - permanent magnetization is not considered. The amplitude of the anomaly is proportional to the mass of the object. For example, a ton of iron buried 15 feet beneath the sensor would create an anomaly of about 500 gammas. Corrosion or rusting may significantly reduce the intensity of an anomaly by reducing the mass of magnetic material.

D-1.2 Survey

The survey areas are squares 80 feet on a side. Measurements were made on a 5-foot grid, producing a total of 289 grid points for each site. The grid was laid out by means of compass, transit, and steel tape. The magnetometer was a Geometrics Model G816 proton precession instrument, which has a resolution of 1 gamma.

Most magnetometer surveys started in the southwest corner and proceeded northward, making a minimum of two measurements at each grid point. Subsequent traverses were made in alternating southward and northward directions, as



EXPLANATION

COMPUTER SIMULATION OF MAGNETIC ANOMALIES FOR A BURIED STEEL DRUM AT TWO DEPTHS OF BURIAL. MAGNETIC SENSOR IS 3' ABOVE GROUND SURFACE. DOTS IN GRID ARE AT 5 SPACING.

Ertec The Earth Technology Corporation	PROJECT NO.: 82-160 USATHAMA DRILL SITE SURVEYS

THEORETICAL MAGNETIC ANOMALIES

4-82

FIGURE 1

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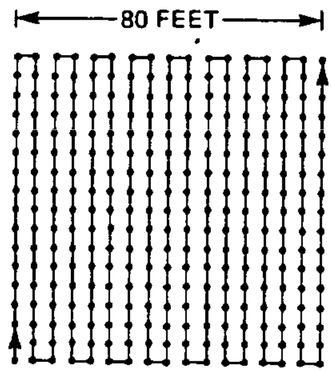
shown in Figure 2. The magnetic sensor was carried in a back pack, with the instrument console supported on the operator's chest by shoulder straps. All magnetic materials were removed from the operator's body, and each measurement was taken while facing in the direction which produced maximum signal strength for the sensor, the response of which is somewhat directional. At each grid point the location, the time, two magnetic readings, and possible comments were recorded. Comments noted the presence of metallic objects, electrical wires, or other relevant facts.

D-1.3 Drift

The geomagnetic field is not constant. It undergoes a diurnal variation of about 50 gammas and has unpredictable variations (micropulsations) of a few minutes duration and a few gammas of amplitude. Magnetic storms are always possible. They can last a day or more and can create amplitude fluctuations of 100 gammas or more. In order to remove such temporal fluctuations (drift) from the survey data, it is necessary to record magnetic intensity at a sationary base station during the survey and subtract the base station values from the survey values. A continuous-recording base station magnetometer, a Geometrics Model G826 proton precession instrument, was operated throughout each survey day. In addition, for surveys S-6, S-7, and S-9, repeated measurements were made at the center of the survey area after each traverse. It was found that the repeated measurements at the center of the survey site gave a significantly better estimate of the drift than the continuous recorder situated a few miles away. The effect of incomplete drift correction shows on some of the low-relief magnetic contour maps as small-amplitude lineations parallel to the survey lines. They do not affect detection capability.



5-FOOT GRID

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USATHAMA
DRILL SITE SURVEYS

SURVEY TRAVERSE PATTERN
USED FOR ALL SITES

2-82

FIGURE 2

D-1.4 Data Processing

As each site survey was completed, the data were sent to Ertec's office in Long Beach, California, for processing and interpretation. Data processing consisted of coding the data for Ertec's Harris 800 computing system, averaging the magnetometer readings for each grid point, interpolating between drift measurements, subtracting the drift from the survey data, and machine-contouring the processed data. Figures 3 through 9 show the resultant magnetic intensity patterns.

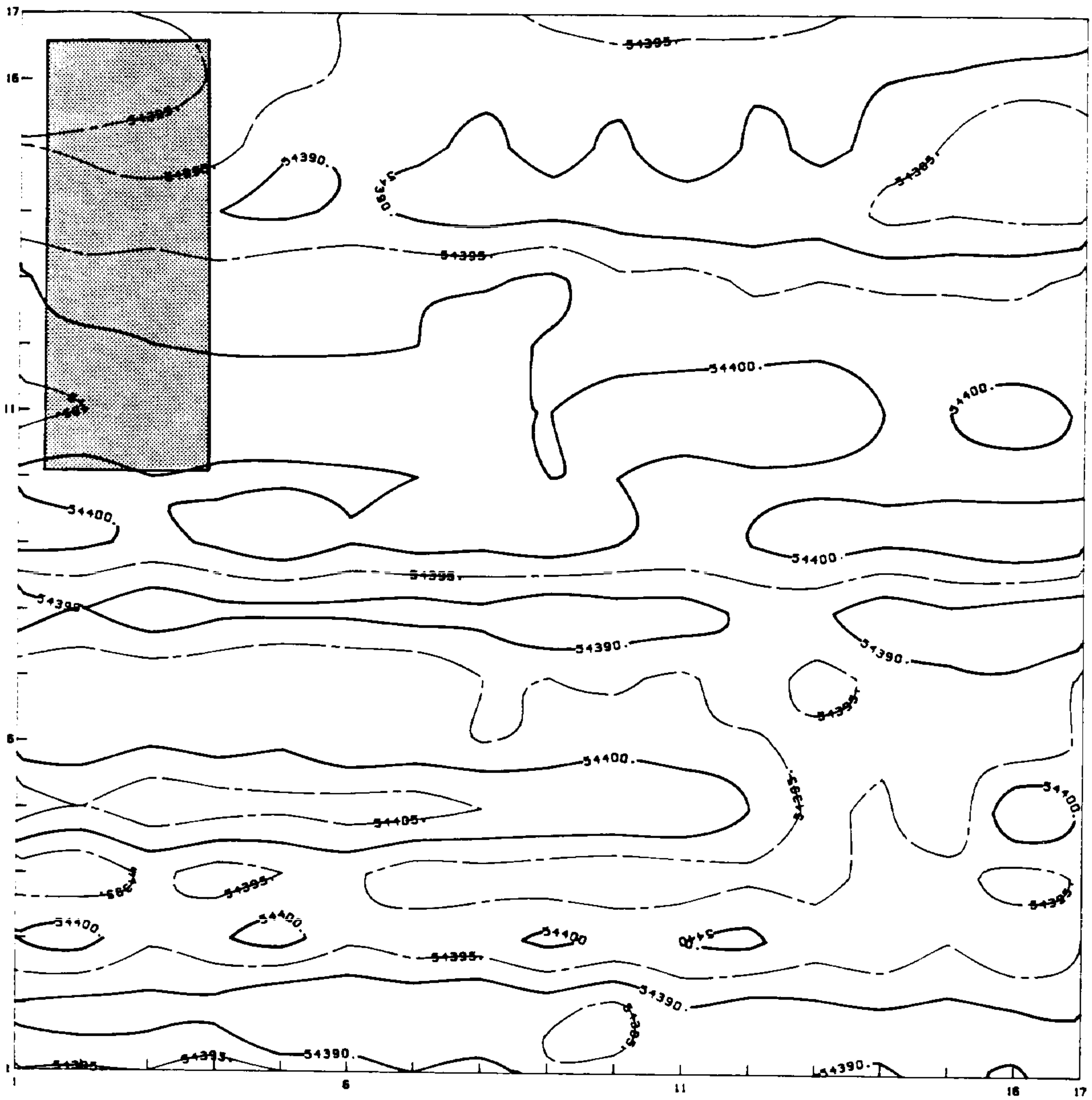
A contour interval of 5 gammas was chosen for all survey sites except N-6NEW, for which a 100 gamma contour interval was necessary to depict the exceptionally large anomalies there. Some sharp corners appear in the contours of the low-relief maps; they are the natural consequence of contouring integer data having only a few units of variation.

D-1.5 Analysis

Analysis of the magnetic contour maps for the purpose of selecting a safe drilling site consists simply of avoiding areas of magnetic relief and seeking the flattest and most uneventful areas. The uneventful areas are shown as shaded areas on the maps in Figures 3 through 9.

All sites, with the exception of N-6NEW, have drillable areas. Site N-6NEW shows high magnetic relief over the entire area, especially in the southeast corner, where a 3000-gamma anomaly indicated the presence of several tons of iron, or its equivalent.

It must be noted that the original site for N-6 was considered inadequate for drilling for reasons unrelated to the magnetometer survey results. After

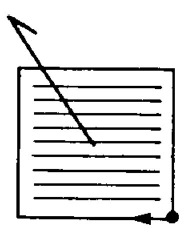


AREA CONSIDERED SAFE FOR DRILLING

10 FEET

CONTOUR INTERVAL: 5 GAMMA

MAGNETIC NORTH



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USATHAMA
DRILL SITE SURVEYS

MAGNETIC ANOMALY MAP
SITE N-4

2-82

FIGURE 3

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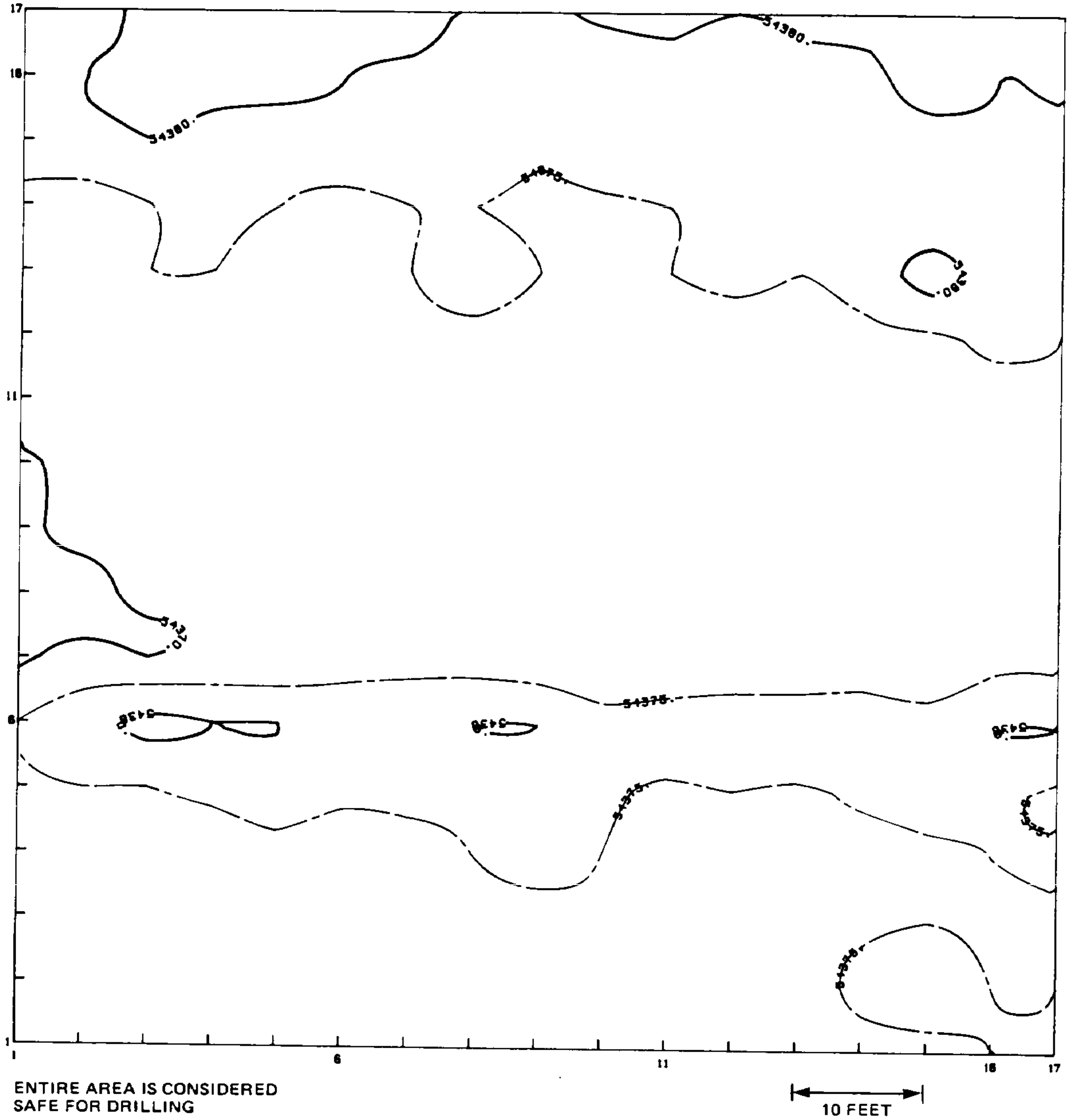
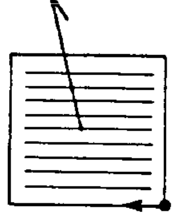


ENTIRE AREA IS CONSIDERED
SAFE FOR DRILLING

CONTOUR INTERVAL: 5 GAMMA



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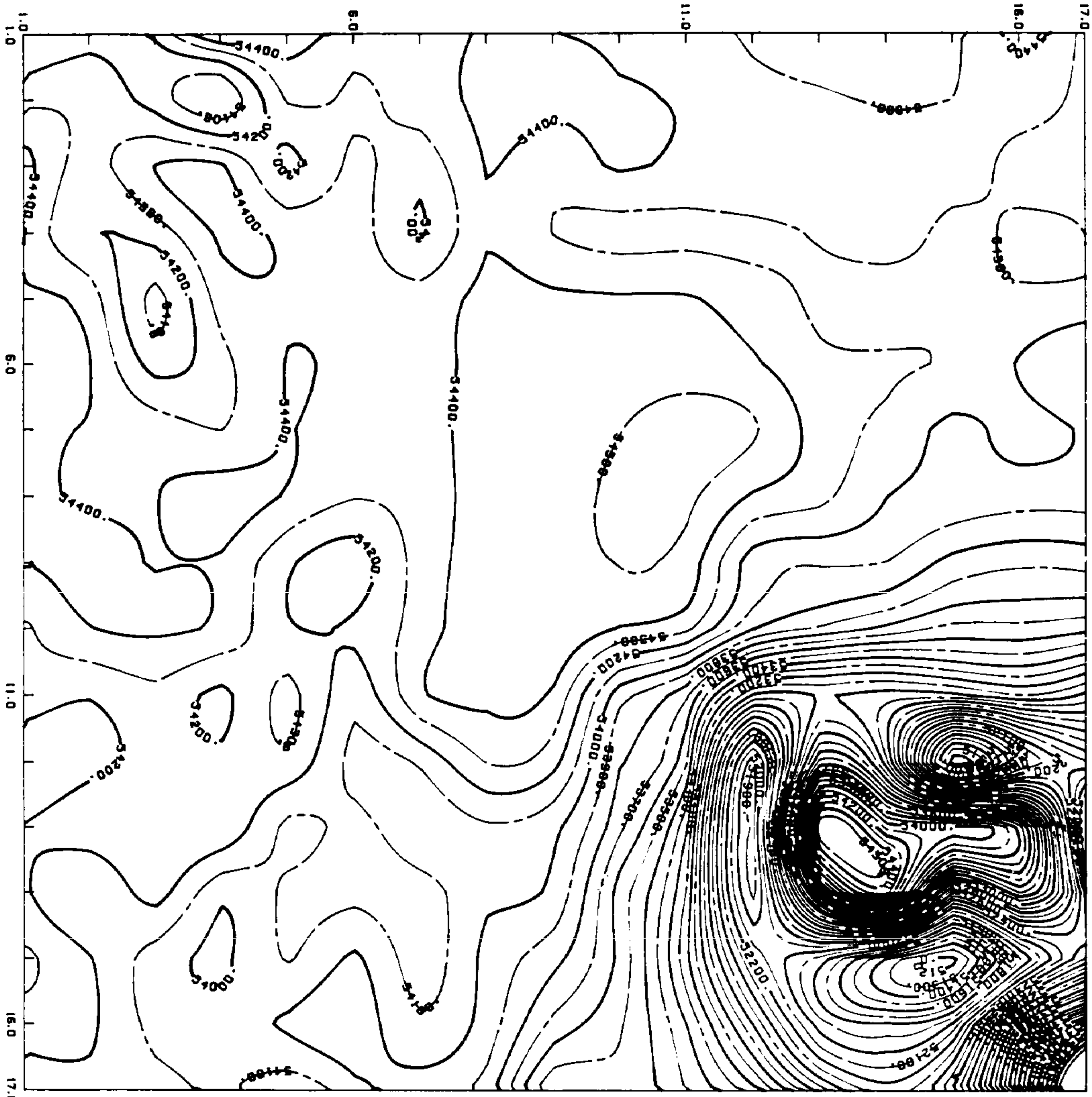
USATHAMA
DRILL SITE SURVEYS

MAGNETIC ANOMALY MAP
SITE N-6

2-82

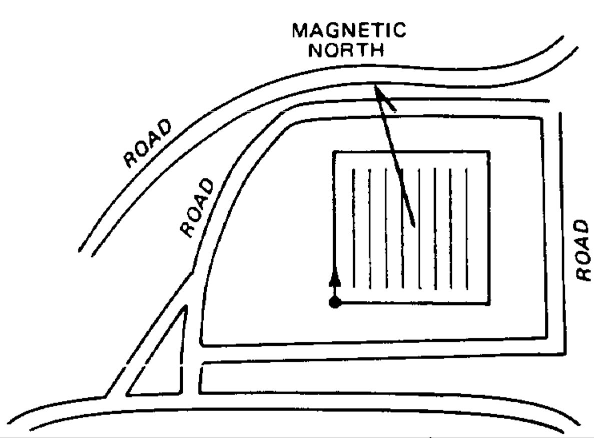
FIGURE 4



ENTIRE AREA IS CONSIDERED
UNSAFE FOR DRILLING

10 FEET.

CONTOUR INTERVAL: 100 GAMMA



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USATHAMA
DRILL SITE SURVEYS

MAGNETIC ANOMALY MAP
SITE N-6 NEW

2-82

FIGURE 5

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Checked by
Drawn by

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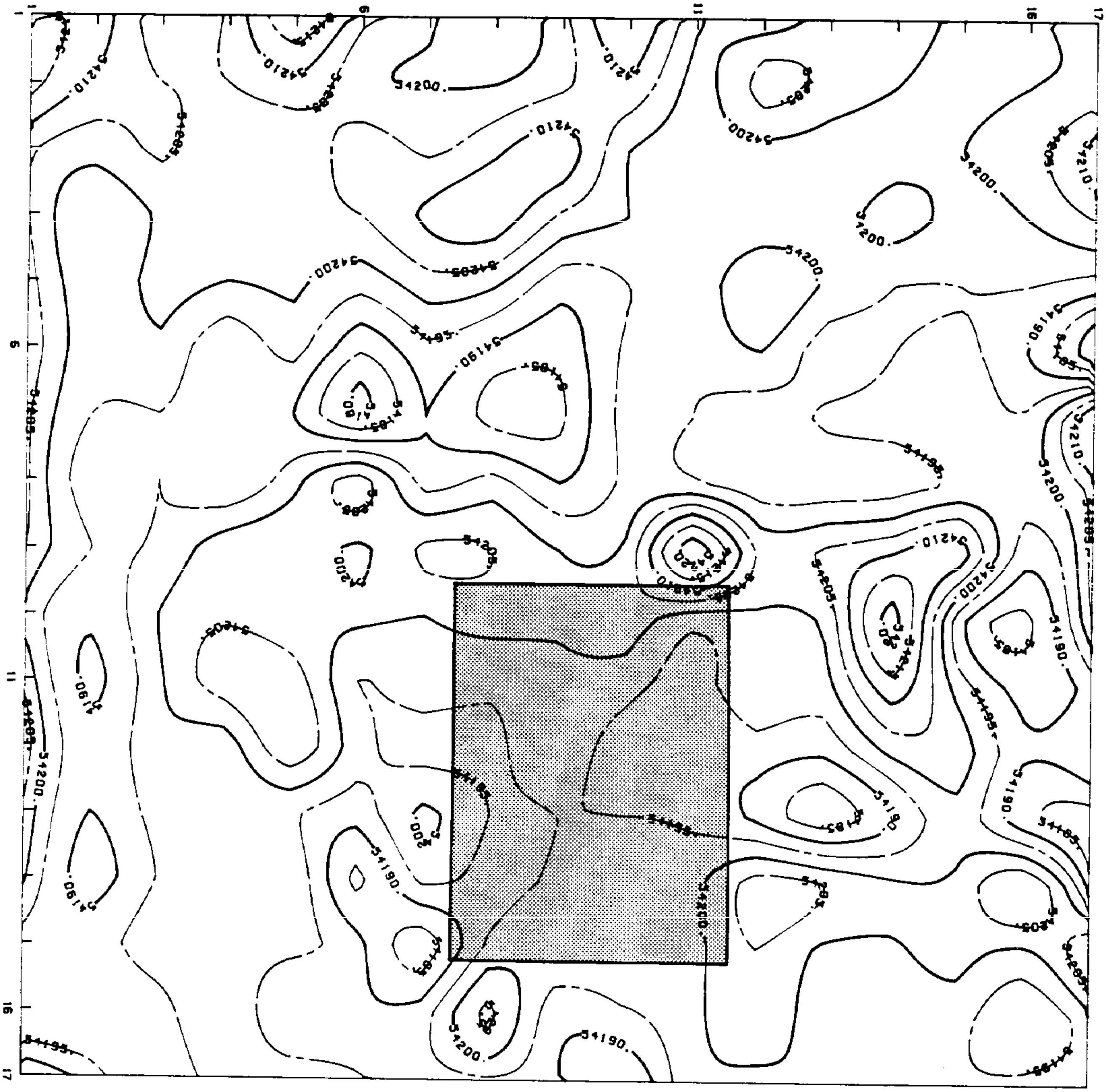
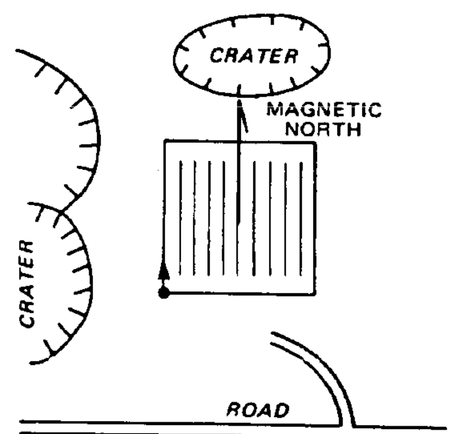


AREA CONSIDERED SAFE FOR DRILLING

10 FEET

CONTOUR INTERVAL: 5 GAMMA



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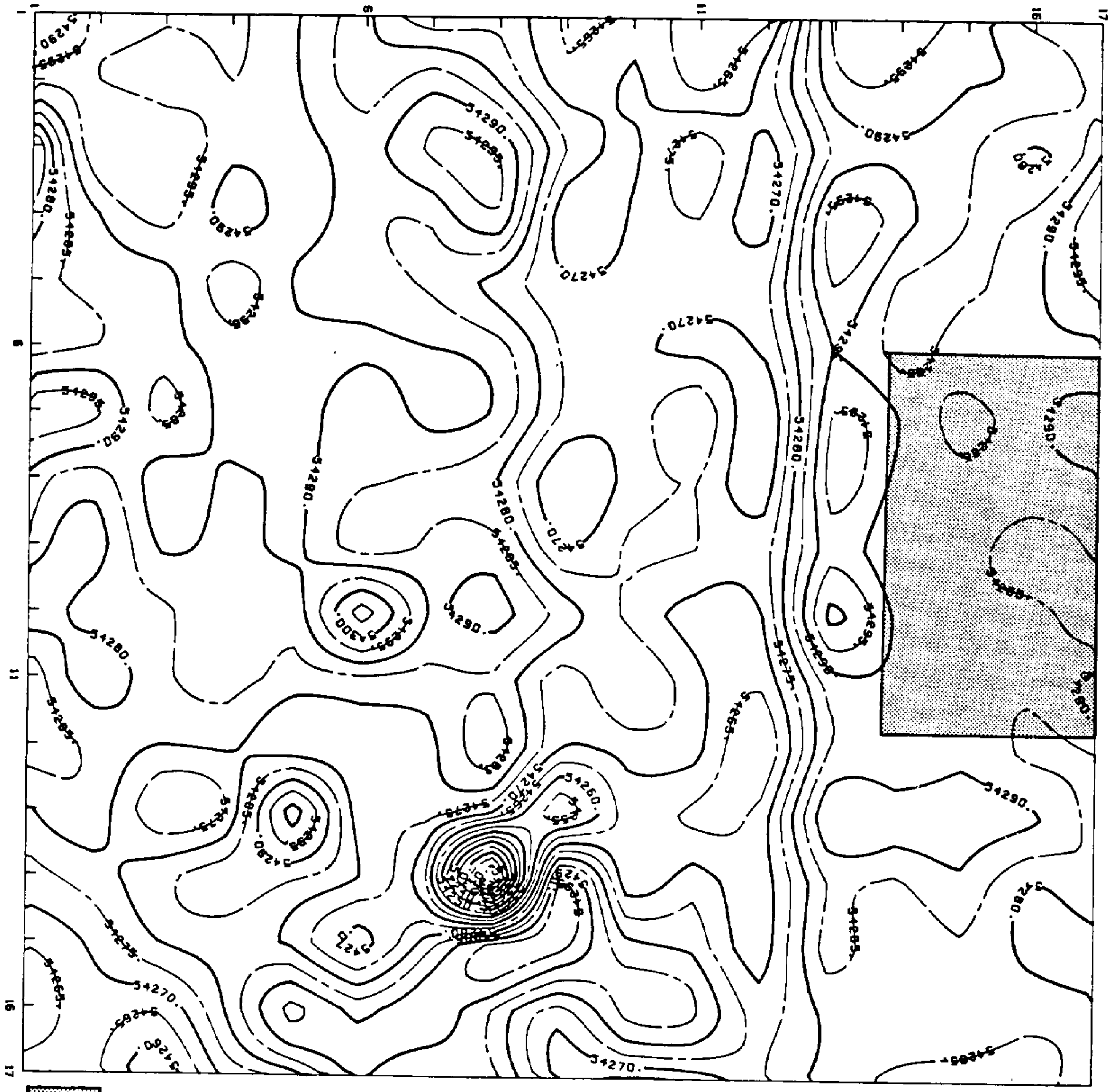
USATHAMA
DRILL SITE SURVEYS

MAGNETIC ANOMALY MAP
SITE S-6

4-82

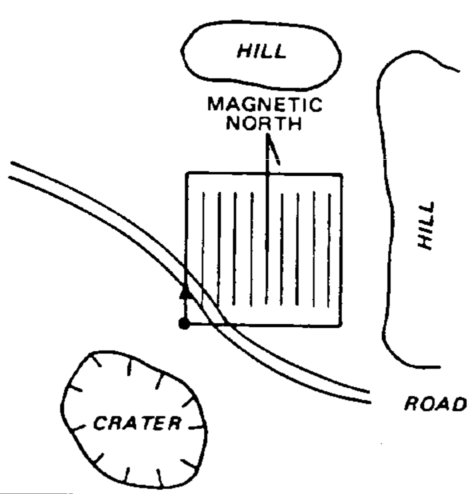
FIGURE 6



AREA CONSIDERED SAFE
FOR DRILLING

10 FEET

CONTOUR INTERVAL: 5 GAMMA



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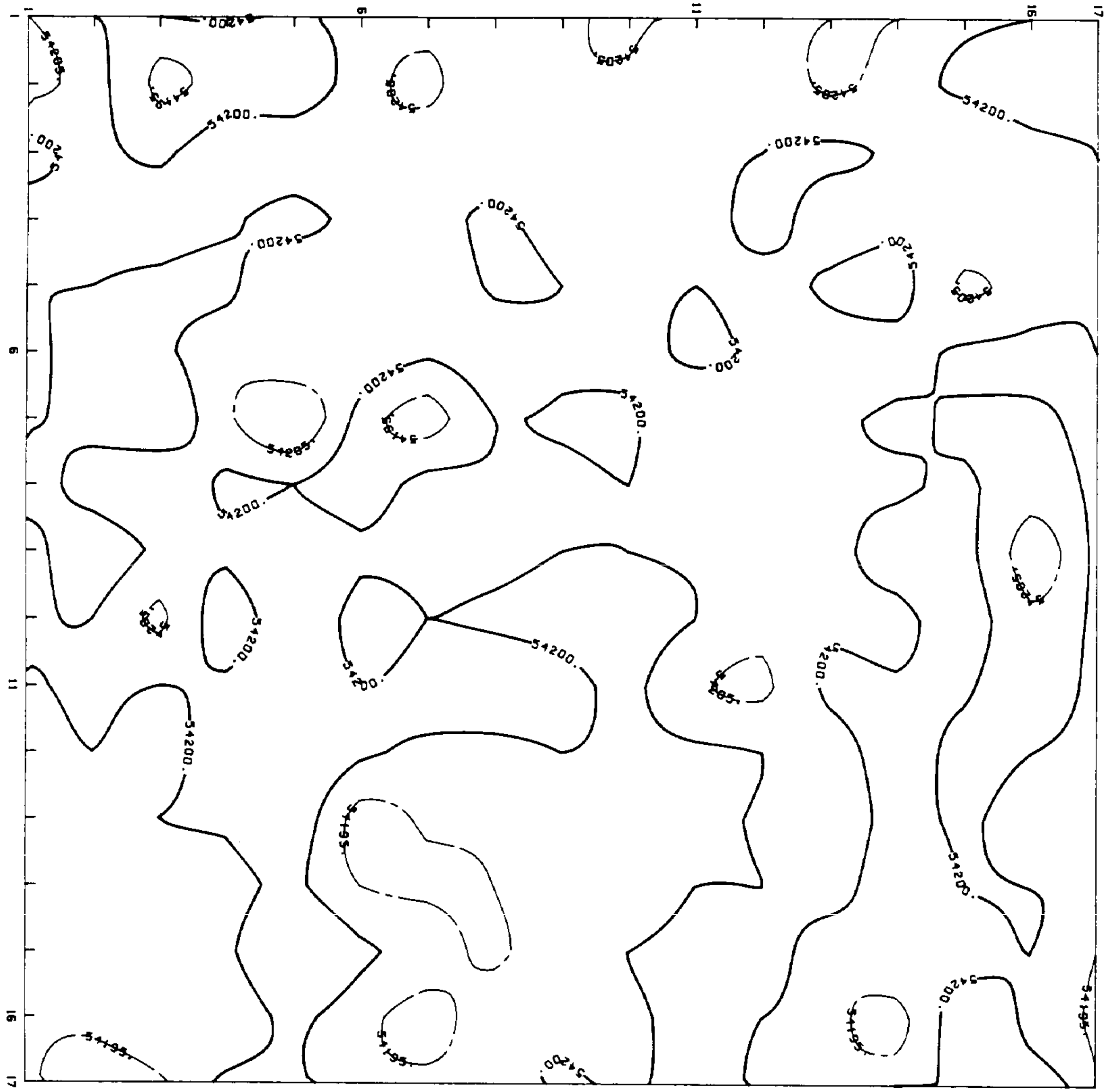
USATHAMA
DRILL SITE SURVEYS

MAGNETIC ANOMALY MAP
SITE S-7

2-82

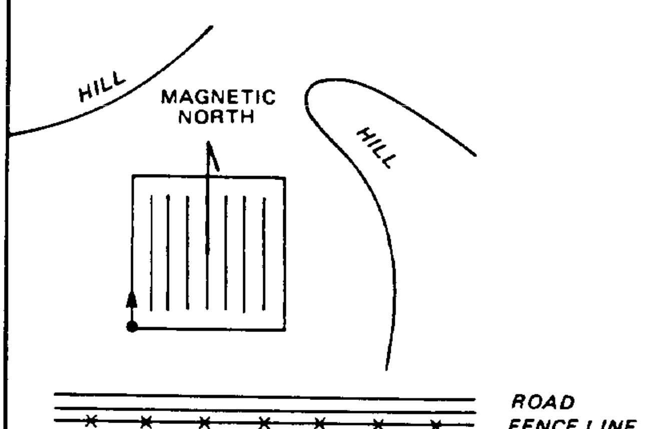
FIGURE 7



ENTIRE AREA IS CONSIDERED
SAFE FOR DRILLING

10 FEET

CONTOUR INTERVAL: 5 GAMMA



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USATHAMA
DRILL SITE SURVEYS

MAGNETIC ANOMALY MAP
SITE S-9

2-82

FIGURE 8

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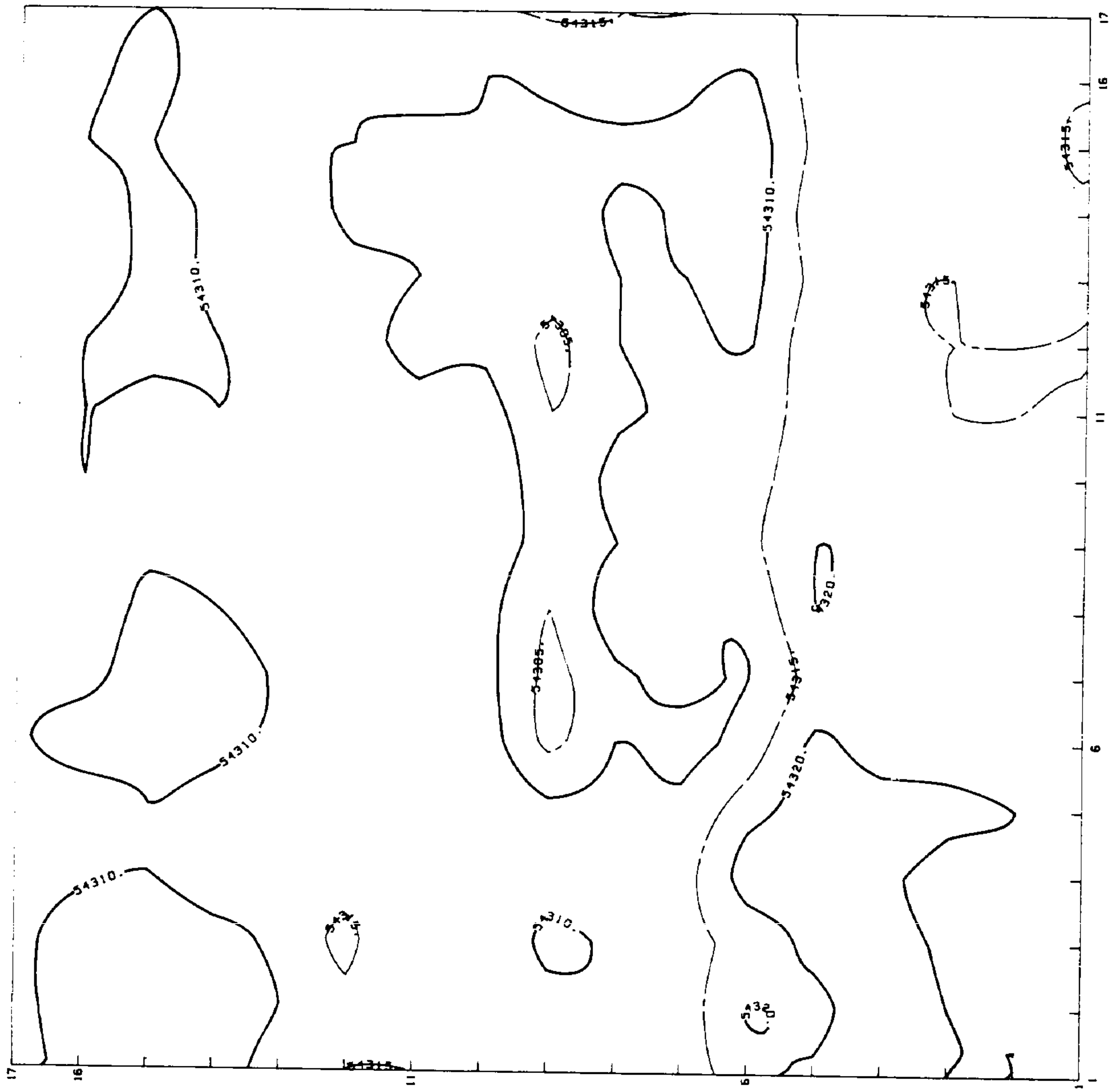
Checked by ______
Drawn by ______
Comp. ______



ENTIRE AREA IS CONSIDERED SAFE FOR DRILLING

10 FEET

CONTOUR INTERVAL: 5 GAMMA

FENCE LINE
ROAD

MAGNETIC NORTH

Ertec
The Earth Technology Corporation

PROJECT NO.: 82-160

USATHAMA
DRILL SITE SURVEYS

MAGNETIC ANOMALY MAP
SITE S-15

2-82

FIGURE 9

Drawn by ______ ...ked by ______ Approved by ______ Comp.

further field investigation upon obtaining new aerial photos of the area, it was decided by Ertec that well N-6 should be re-located further west. Hence, the magnetometer survey for N-6NEW. Since no area could be established that would be safe for drilling, N-6 was again re-located to a more suitable area where little danger of UXO's existed.

D-2 Gravity Survey

D-2.1 Introduction

A gravity survey was conducted at the Tooele Army Depot from the period December 7th through 17th, 1981. The purpose of the survey was to obtain gravity data to provide a conceptual model of the contact between unconsolidated basin fill materials and the underlying bedrock. This model, together with the results of hydrologic studies, would provide information to understand the ground-water flow regime and pathways that transport and distribute potential pollutants. The preliminary gravity results were used to select locations for seismic refraction survey lines and electrical resistivity soundings. Data from the refraction lines corroborated the gravity interpretation.

The gravity survey consists of measurements made at stations. Each field gravimeter measurement was corrected for instrument and tidal drift, as well as latitude, elevation, and terrain effects. Gravimeter units were related to absolute gravity by repeated measurements at Clover Base in nearby Clover, Utah (Cook, et. al., 1971). The gravity at Clover Base is given as 979,698.71 milligals and we have calculated that the Simple Bouguer Anomaly there is -202.49 milligals.

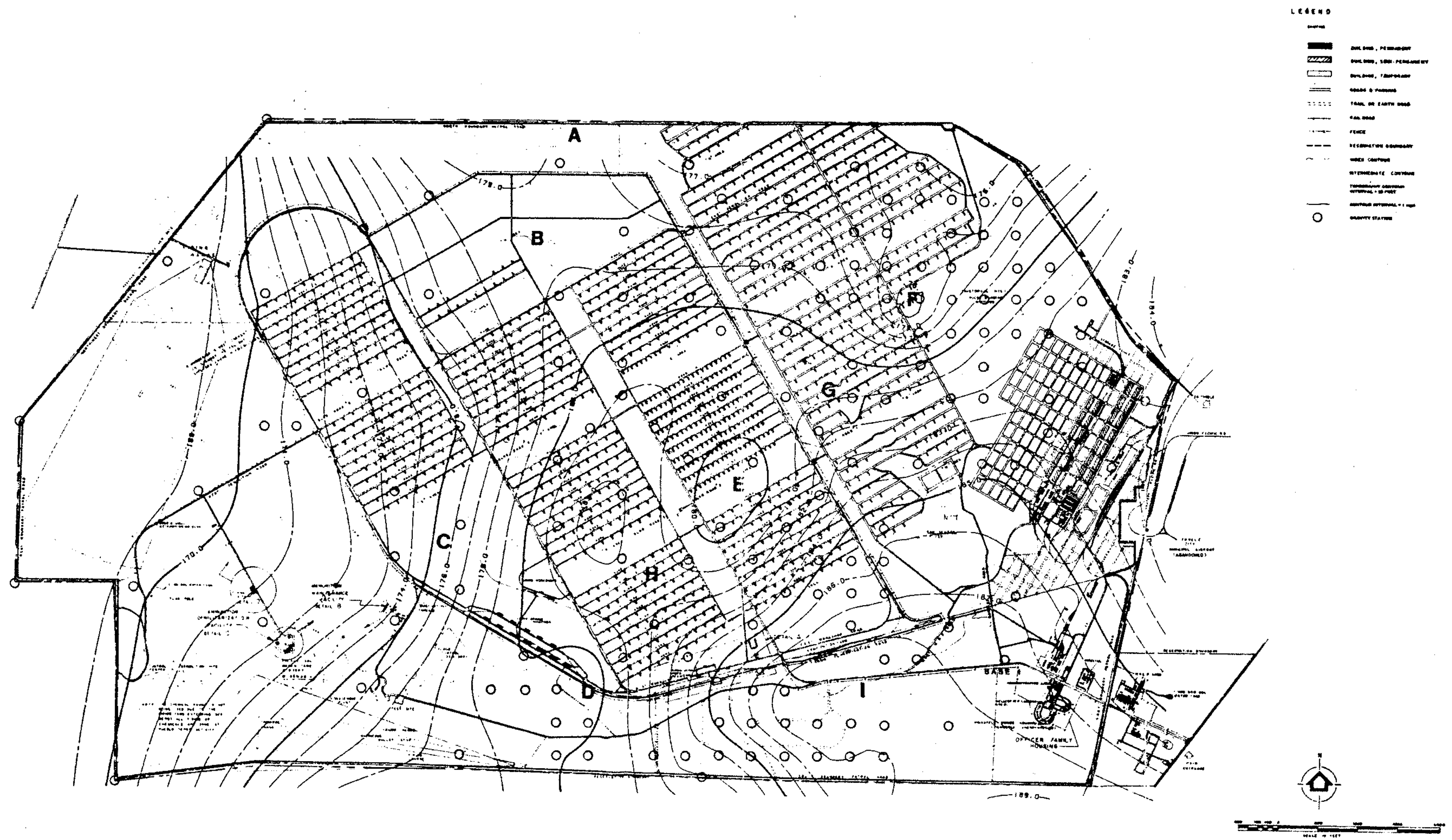
The gravity station locations are given as coordinates on the TEAD survey grid (a network of pre-1942 monuments), for example: x = -14,300 ft, y = 15,600 ft, locates a station west and south of the coordinate origin at the east-central boundary of the Depot. Elevations and locations, are inscribed on the survey monuments.

The data were collected by a two-man field crew with a pickup truck, gravimeter, and transit. Most gravity measurements were taken at survey monuments. For those stations, surveying was unnecessary. There was some difficulty in searching out monuments hidden in tall grass, and some monuments were missing.

Where there were no monuments, measurements were made at points that could be located on the base map, or located from such points by transit survey. Elevations for these points were taken from the contours of a topographic map.

D-2.2 Analysis of the Tooele Gravity Data

A contour map of terrain-corrected Bouguer (gravitational) Anomaly (Complete Bouguer Anomaly or CBA) is shown in Plate 1. Terrain corrections were done for a distance of 32,490 feet (the equivalent of Zone K on the Hammer Chart; see for example: Dobrin, 1976). Corrections for greater distances from the station were not done because the correction factor became the same for every station within the survey area. The terrain-corrected data were gridded using a minimum curvature algorithm (Briggs, 1974; Swain, 1976) and contoured by computer. This algorithm computes the surface of least curvature which passes through an aribtrarily distributed set of data points and produces an interpolated set of values on a uniform grid suitable for machine contouring. The grid spacing was chosen to be slightly less than the average data spacing.



Ertec
The Earth Technology Corporation

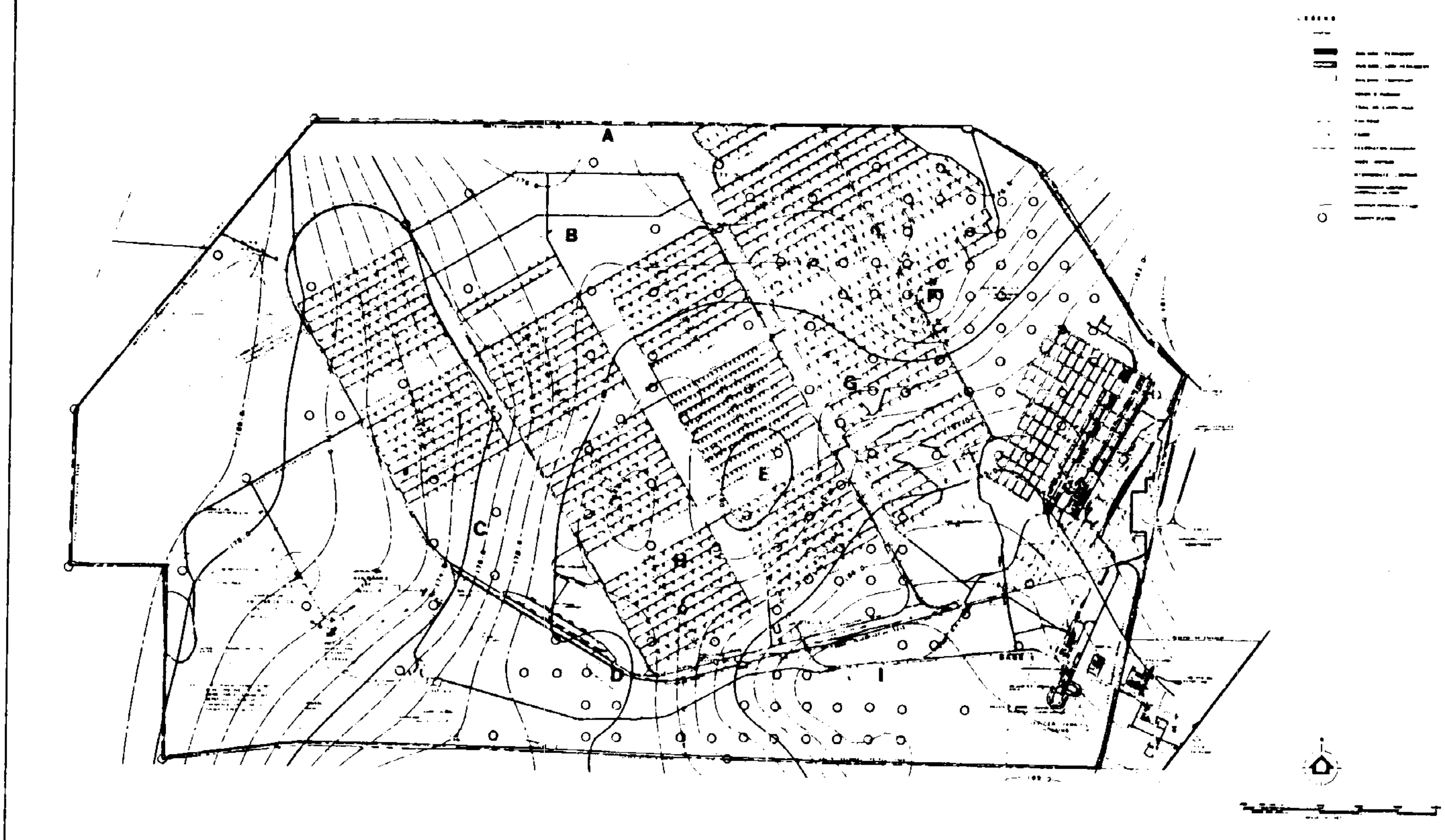
PROJECT NO.: 82-180

TOOLE ARMY DEPOT, USATHAMA

COMPLETE BOUGUER ANOMALY

2-82

PLATE 1



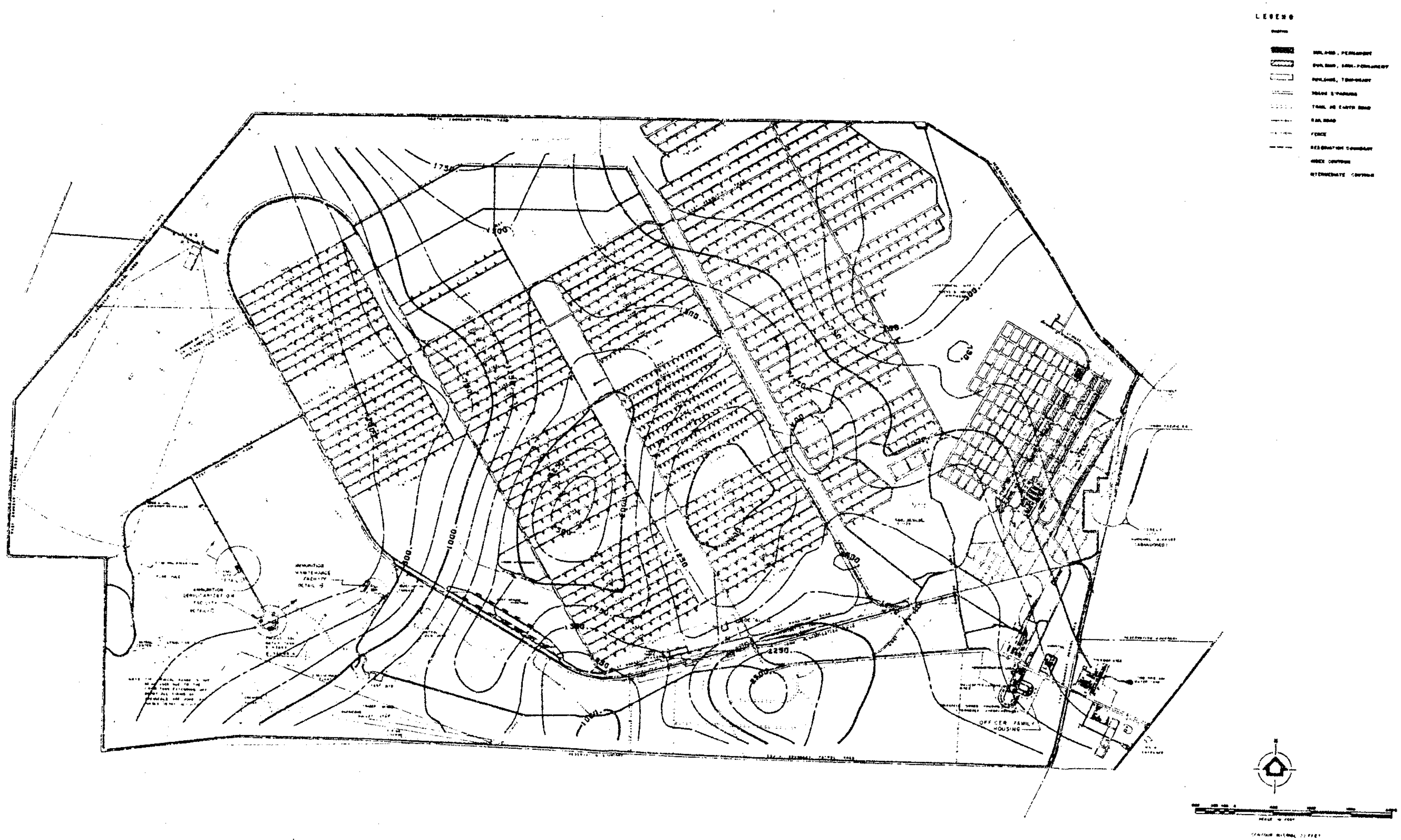
Ertec

PROJECT NO 82-160

TOOLE ARMY DEPOT, USATHAMA

COMPLETE BOUGUER ANOMALY

PLATE 1



Ertec
The Earth Technology Corporation

PROJECT NO.: 82-180

TOOLE ARMY DEPOT, USATHAMA

DEPTH TO BEDROCK AS INTERPRETED FROM GRAVITY DATA

5-82

PLATE 2

four separate reductions, to account for four geometrical effects, are made to the observed gravity at each station to arrive at its Bouguer Anomaly value.

a. Free-Air Effect: Gravitational attraction varies inversely as the square of the distance from the center of the earth. Thus, corrections must be applied for elevation. Observed gravity levels are corrected for elevation using the normal vertical gradient of:

$$FA = 0.09406 \text{ mg/ft } (-0.3086 \text{ milligals/meter})$$

where FA is the free-air effect (the rate of change of gravity with distance from the center of the earth). The free-air correction is positive in sign since the correction is opposite the effect.

b. Bouguer Effect: Like the free-air effect, the Bouguer effect is a function of the elevation of the station, but it considers the influence of a slab of earth materials between the observation point on the surface of the earth and the corresponding point on the geoid (sea level). Normal practice, which is to assume that the density of the slab is 2.67 grams per cubic centimeter, was followed in these studies. The Bouguer correction (B_c), which is opposite in sign to the free-air correction, was defined according to the following formula.

$$B_c = 0.01276 \ (2.67) \ hf \text{ (milligals per foot)}$$

$$B_c = 0.04185 \ (2.67) \ h_m \text{ (milligals per meter)}$$

where h_f is the height above sea level in feet and hm is the height in meters.

c. Latitude Effect: Points at different latitudes will have different values of gravity to two reasons. The earth (and the geoid) is spheroidal, or flattened at the poles. Since points at higher latitudes are closer to the center of the earth than points near the equator, gravity at the higher latitudes is larger. As the earth spins, the centrifugal accerlation causes a slight decrease in the measured value of gravity. At the higher latitudes where the earth's circles of latitude are smaller, the centrifugal acceleration diminishes. The gravity formula for the Geodetic Reference System, 1967, gives the theoretical value of gravity at the geoid as a function of latitude. It is:

$$g = 978.0281 \, (1 + 0.0053204 \sin^2 o - 0.0000058^2 2o) \text{ gals}$$

where g is the theoretical acceleration of gravity and o is the latitude in degrees. The positive term accounts for the spheroidal shape of the earth. The negative term adjusts for the centrifugal acceleration.

The previous two corrections (free air and Bouguer) adjust the observed gravity to the value it would have at the geoid (sea level). The theoretical value at the geoid for the latitude of the station is subtracted from the adjusted observed gravity and the remainder is called the Simple Bouguer Anomaly (SBA). Most of this represents the effect of material beneath the station, but part of it may be due to irregularities in terrain (upper part of the Bouguer slab) around the station.

d. Terrain Effect: Topographic relief around the station has a negative effect on the gravitational force at the station. A nearby hill has upward gravitational pull and nearby valley contributes less downward attraction than a nearby material would have. Therefore, the corrections are always positive. Corrections are made to the SBA when the terrain effects are 0.1 milligal or larger. Terrain corrected Bouguer values are called the Complete Bouguer Anomaly (CBA). When the CBA is obtained, the reduction of gravity at individual measurement points (stations) is complete.

D-2.5 Method of Interpretation

D-2.5.1 Regional - Residual Separation

To interpret the gravity data, the portion of the CBA that might be caused by the light-weight, basin-fill material must be separated from that caused by the heavier bedrock material which forms the surrounding mountains and presumably the basin floor. The first step is to estimate a regional field. This is an estimtion of the values the CBA would have if the light-weight sediments (the anomaly) were not there. Since the valley-fill sediments are absent at the stations read in the mountains, one approach is to use the CBA values at bedrock stations as the basis for constructing a second-order polynomial surface to represent a retional field over the valley.

Where there are insufficient bedrock stations to define a satisfactory regional trend, another approach is to estimate the regional by the process of upward continuation of the CBA field. A principal result of potential field theory is that a field quantity satisfying Laplace's equation in a three-dimensional volume of space is specified completely by the value it has on the surface bounding that volume (Grant and West, 1965). Since the gravitational field statisfies Laplace's equation, its value anywhere above the surface of the earth can be found using only the value of gravity on the surface of the earth, regardless of the mass distribution that produces the value of gravity in the first place. On this basis, the Bouguer anomaly is readily continued to level surfaces above the ground.

An important property of upward continuation is that the resultant field (which can be represented by a contour map), changes more with respect to shallow sources than it does with respect to deeper souces. The anomalous parts of the field ascribed to shallow density distribution tend to vanish as the continuation is carried upward; whereas the field produced by deeper sources changes only slightly, so that upward continuation produces regional-type fields.

The difference between the CBA and the regional field is called the residual field or residual anomaly. The residual field is the interpreter's estimation of the gravitational effect of the geologic anomaly.

D-2.5.2 Interpretation of the Residual Anomaly

If the regional is well chosen, the magnitude of the residual anomaly is a function of the thickness of the anomalous (fill) material and the density contrast. The density contrast is the difference in density between the alluvial and bedrock material. If this contrast were known exactly, an accurate calculation of the thickness could be made. Generally, the densities are not well known and vary within the study area. Therefore, it is necessary to use densities typical of materials similar to those in the study area.

If the selected average density contrast is smaller than the actual density contrast, the computed depth to bedrock will be greater than the actual depth and vice-versa. The computer depth is inversely proportional to the density contrast. A ten percent error in density contrast produces a ten percent error is computed depth.

Once the density contrast betwen the alluvium and bedrock is established, there are several methods available for determining the form of the alluvium-bedrock interface. One way is to use an interative computer porogram which will yield some simple model of the interface approximtely explaining the residual gravity anomaly (Dordell, 1970). An alternative approach is to assume the form of the interface a priori and calcuate what effect this would have on the residual gravity anomaly. By continually adjusting the model, one may obtain a reasonable estimate of the interface. There are computer programs that will calculate the gravitational effect of two-dimensional (Talwani, et al., 1959) and three-dimensional (Cordell, 1970; Plouff, 1975) bodies.

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Gravity Survey Data

SIMPLE AND COMPLETE BOUGUER ANOMALIES ASSUMING A DENSITY OF 2.67
GRAVITY SURVEY DONE AT TOOELE, UTAH

X, Y= POSITIONS ON LOCAL COORDINATE SYSTEM (FEET) T=TERRAIN CORRECTION

ID	X	Y	SBA	T	CBA
1	-6870.000	-10670.000	-192.580	3.327	-189.254
2	-16900.000	-11700.000	-191.013	2.600	-188.413
3	-16900.000	-13000.000	-191.001	2.541	-188.460
4	-15600.000	-13000.000	-192.424	2.513	-189.911
5	-14300.000	-13000.000	-193.245	2.558	-190.687
6	-13000.000	-13000.000	-193.109	2.649	-190.460
7	-18200.000	-13000.000	-189.394	2.566	-186.828
8	-19500.000	-14300.000	-188.245	2.812	-185.433
9	-18200.000	-14300.000	-188.615	2.932	-185.684
10	-16900.000	-14300.000	-189.831	3.004	-186.827
11	-15600.000	-14300.000	-191.439	2.845	-188.594
12	-14300.000	-14300.000	-192.498	2.852	-189.646
13	-13000.000	-14300.000	-192.729	2.899	-189.830
14	-11700.000	-14300.000	-192.788	3.088	-189.700
15	-26000.000	-10400.000	-184.063	2.560	-181.503
16	-24700.000	-11700.000	-182.937	2.608	-180.329
17	-23400.000	-13000.000	-184.263	2.826	-181.438
18	-23400.000	-14300.000	-185.044	2.937	-182.107
19	-20800.000	-14300.000	-186.425	2.962	-183.463
20	-9100.000	0.000	-184.871	1.869	-183.002
21	-9100.000	2600.000	-181.638	1.538	-180.100
22	-9100.000	3900.000	-179.893	1.395	-178.498
23	-7800.000	0.000	-185.254	2.058	-183.196
24	-10400.000	2600.000	-181.092	1.681	-179.411
25	-10400.000	3900.000	-179.024	1.543	-177.481
26	-11700.000	5200.000	-179.187	1.658	-177.529
27	-9100.000	6500.000	-179.187	1.454	-177.733
28	-9100.000	7800.000	-178.304	1.419	-176.885
29	-7800.000	6500.00C	-179.282	1.521	-177.761
30	-6500.000	6500.000	-180.614	1.327	-179.287
31	-9100.000	5200.000	-178.891	1.419	-177.473
32	-10400.000	3900.000	-176.839	1.543	-175.296
33	-13000.000	5200.000	-179.872	1.465	-178.407
34	-14300.000	3900.000	-181.320	1.521	-179.799
35	-7800.000	2600.000	-183.410	1.579	-181.831
36	-6500.000	2600.000	-183.864	1.607	-182.257
37	-3900.000	2600.000	-185.382	1.676	-183.706
38	-7800.000	1300.000	-184.088	1.772	-182.316
39	-7800.000	5200.000	-180.191	1.416	-178.775
40	-7800.000	7800.000	-178.190	1.497	-176.693
41	-6500.000	7800.000	-179.542	1.274	-178.268
42	-6500.000	5200.000	-181.736	1.376	-180.360
43	-10400.000	9100.000	-178.015	1.489	-176.526
44	-11700.000	7800.000	-178.853	1.581	-177.272
45	-13000.000	6500.000	-179.637	1.457	-178.180
46	-11700.000	6500.000	-179.214	1.582	-177.632
47	-10400.000	7800.000	-178.685	1.457	-177.228

48	-16900.000	5200.000	-181.172	1.780	-179.392
49	-13000.000	-2600.000	-186.338	2.074	-184.264
50	-13000.000	0.000	-183.546	2.051	-181.495
51	-15600.000	0.000	-182.965	1.770	-181.195
52	-15600.000	2600.000	-182.597	1.690	-180.907
53	-14300.000	-1300.000	-184.209	1.993	-182.216
54	-13000.000	1300.000	-182.761	1.724	-181.037
55	-11700.000	3900.000	-179.654	1.683	-177.971
56	-13000.000	3900.000	-180.617	1.552	-179.065
57	-19500.000	6500.000	-179.822	1.422	-178.400
58	-15600.000	7800.000	-179.527	1.374	-178.153
59	-13000.000	9100.000	-179.278	1.375	-177.903
60	-19500.000	9100.000	-178.197	1.344	-176.853
61	-18200.000	7800.000	-179.039	1.325	-177.714
62	-15600.000	-11700.000	-192.312	2.520	-189.792
63	-10400.000	-10400.000	-192.623	2.652	-189.971
64	-9100.000	-9100.000	-191.722	2.677	-189.045
65	-11700.000	-6500.000	-189.061	2.495	-186.566
66	-11700.000	-5200.000	-189.515	2.465	-187.050
67	-10400.000	-2600.000	-187.871	3.350	-184.521
68	-7800.000	-2600.000	-188.245	2.219	-186.026
69	-5200.000	2600.000	-184.467	1.621	-182.846
70	-22100.000	6500.000	-180.113	1.386	-178.727
71	-24700.000	3900.000	-181.110	1.593	-179.517
72	-22100.000	3900.000	-181.087	1.523	-179.564
73	-24700.000	1300.000	-181.624	1.699	-179.925
74	-23400.000	-1300.000	-183.146	1.978	-181.168
75	-22100.000	0.000	-183.268	1.686	-181.582
76	-22100.000	1300.000	-182.533	1.630	-180.903
77	-19500.000	3900.000	-181.764	1.541	-180.223
78	-18200.000	2600.000	-182.538	1.569	-180.969
79	-18200.000	0.000	-182.937	1.765	-181.172
80	-20800.000	-1300.000	-183.912	1.841	-182.071
81	-16900.000	-2600.000	-182.412	2.026	-180.386
82	-19500.000	-6500.000	-184.163	2.371	-181.792
83	-20800.000	-9100.000	-185.733	2.517	-183.216
84	-15600.000	-7800.000	-187.309	2.339	-184.970
85	-14300.000	-6500.000	-187.784	2.459	-185.325
86	-16900.000	-6500.000	-184.891	2.611	-182.280
87	-15600.000	-5200.000	-184.915	2.240	-182.675
88	-18200.000	-5200.000	-182.942	2.554	-180.388
89	-14300.000	-3900.000	-185.711	3.301	-182.410
90	-19500.000	-2600.000	-183.563	2.436	-181.127
91	-22100.000	-6500.000	-185.280	2.339	-182.941
92	-24700.000	-5200.000	-184.476	2.163	-182.313
93	-19500.000	-10400.000	-187.076	2.563	-184.513
94	-16900.000	-9100.000	-187.937	3.009	-184.928
95	-13000.000	-6500.000	-189.410	2.414	-186.996
96	-5200.000	3900.000	-184.338	1.513	-182.825
97	-6500.000	3900.000	-183.150	1.466	-181.684
98	-3900.000	3900.000	-185.141	1.575	-183.566
99	-5200.000	5200.000	-183.105	1.415	-181.690
100	-7800.000	3900.000	-181.701	1.478	-180.223
101	-14300.000	-7800.000	-188.775	2.668	-186.107
102	-13000.000	-7800.000	-190.306	2.512	-187.794

103	-13000.000	-9100.000	-191.353	2.499	-188.854
104	-11700.000	-7800.000	-190.763	2.594	-188.169
105	-22100.000	-3900.000	-184.984	2.002	-182.983
106	-24700.000	-2600.000	-182.950	1.945	-181.005
107	-28600.000	-1300.000	-177.595	1.969	-175.626
108	-29900.000	3900.000	-178.800	1.663	-177.137
109	-36400.000	3900.000	-172.911	1.849	-171.062
110	-32500.000	0.000	-175.717	1.926	-173.791
111	-31200.000	-3900.000	-176.724	2.242	-174.482
112	-28600.000	-7800.000	-180.427	2.296	-178.131
113	-28600.000	-5200.000	-179.288	2.225	-177.063
114	-31200.000	-6500.000	-176.652	2.263	-174.389
115	-22100.000	-10400.000	-184.134	2.534	-181.600
116	-24700.000	9100.000	-180.006	1.400	-178.606
117	-29900.000	7800.000	-179.607	1.576	-178.032
118	-9100.000	-13000.000	-193.249	3.201	-190.048
119	-11700.000	-13000.000	-192.974	2.773	-190.201
120	-11700.000	-10400.000	-192.492	2.629	-189.863
121	-6500.000	-7800.000	-191.719	2.874	-188.845
122	-1340.000	128.000	-186.904	2.024	-184.880
123	-38932.000	-4030.000	-173.990	2.101	-171.889
124	-41120.000	-8080.000	-175.556	2.169	-173.387
125	-46540.000	-7410.000	-171.810	2.444	-169.366
126	-46260.000	-964.000	-170.599	2.423	-168.176
127	-36608.000	10776.000	-175.250	1.842	-173.408
128	-40300.000	5200.000	-170.545	1.924	-168.621
129	-42511.000	-15334.000	-176.876	3.200	-173.676
130	-28600.000	-14300.000	-183.324	2.969	-180.355
131	-11700.000	0.000	-183.906	1.937	-181.969
132	-10400.000	5200.000	-178.545	1.510	-177.035
133	-9100.000	5200.000	-178.847	1.419	-177.429
134	-13000.000	5200.000	-179.834	1.465	-178.369
135	-14300.000	5200.000	-180.600	1.466	-179.134
136	-15600.000	5200.000	-180.962	1.443	-179.519
137	-10400.000	1300.000	-183.118	1.860	-181.258
138	-14300.000	3900.000	-181.384	1.521	-179.863
139	-5312.000	0.000	-186.210	1.859	-184.351
140	-3660.000	1300.000	-185.336	1.778	-183.558
141	-4604.000	-1117.000	-186.589	2.046	-184.543
142	-6223.000	-2454.000	-188.184	2.184	-186.000
143	-3084.000	-2704.000	-187.123	2.772	-184.351
144	-31200.000	-9100.000	-178.139	2.336	-175.803
145	-35655.000	-9696.000	-176.768	2.198	-174.570
146	-26000.000	-11700.000	-183.743	2.607	-181.136
147	-27300.000	-11700.000	-183.777	2.592	-181.185
148	-24700.000	-13000.000	-183.250	2.754	-180.496
149	-24700.000	-14300.000	-184.563	2.830	-181.733
150	-32177.000	-11879.000	-180.778	2.400	-178.378
151	-32262.000	6336.000	-177.013	1.608	-175.405
152	-34355.000	-1568.000	-175.299	2.050	-173.249
153	-18886.000	-15115.000	-187.909	2.861	-185.048

SIMPLE AND COMPLETE BOUGUER ANOMALIES ASSUMING A DENSITY OF 2.3
SURVEY AT TOOELE UTAH.

X, Y= LOCATIONS ON LOCAL COORDINATE SYSTEM T=TERRAIN CORRECTION

ID	X	Y	SBA	T	CBA
1	-6870.000	-10670.000	-190.755	3.327	-187.429
2	-16900.000	-11700.000	-189.463	2.600	-186.863
3	-16900.000	-13000.000	-189.154	2.541	-186.613
4	-15600.000	-13000.000	-190.598	2.513	-188.085
5	-14300.000	-13000.000	-191.435	2.558	-188.877
6	-13000.000	-13000.000	-191.310	2.649	-188.661
7	-18200.000	-13000.000	-187.524	2.566	-184.958
8	-19500.000	-14300.000	-186.013	2.812	-183.201
9	-18200.000	-14300.000	-186.565	2.932	-183.634
10	-16900.000	-14300.000	-187.927	3.004	-184.923
11	-15600.000	-14300.000	-189.549	2.845	-186.704
12	-14300.000	-14300.000	-190.625	2.852	-187.773
13	-13000.000	-14300.000	-190.861	2.899	-187.962
14	-11700.000	-14300.000	-190.912	3.088	-187.824
15	-26000.000	-10400.000	-182.737	2.560	-180.177
16	-24700.000	-11700.000	-181.440	2.608	-178.832
17	-23400.000	-13000.000	-182.550	2.826	-179.725
18	-23400.000	-14300.000	-182.976	2.937	-180.039
19	-20800.000	-14300.000	-184.268	2.962	-181.306
20	-9100.000	0.000	-183.870	1.869	-182.001
21	-9100.000	2600.000	-180.663	1.536	-179.125
22	-9100.000	3900.000	-178.901	1.395	-177.506
23	-7800.000	0.000	-184.102	2.058	-182.044
24	-10400.000	2600.000	-180.289	1.681	-178.608
25	-10400.000	3900.000	-178.264	1.543	-176.721
26	-11700.000	5200.000	-178.642	1.658	-176.984
27	-9100.000	6500.000	-178.568	1.454	-177.114
28	-9100.000	7800.000	-177.786	1.419	-176.367
29	-7800.000	6500.000	-178.522	1.521	-177.001
30	-6500.000	6500.000	-179.693	1.327	-178.366
31	-9100.000	5200.000	-178.121	1.419	-176.703
32	-10400.000	3900.000	-176.078	1.543	-174.535
33	-13000.000	5200.000	-179.363	1.465	-177.898
34	-14300.000	3900.000	-180.811	1.521	-179.290
35	-7800.000	2600.000	-182.305	1.579	-180.726
36	-6500.000	2600.000	-182.679	1.607	-181.072
37	-3900.000	2600.000	-184.023	1.676	-182.347
38	-7800.000	1300.000	-182.939	1.772	-181.167
39	-7800.000	5200.000	-179.256	1.416	-177.840
40	-7800.000	7800.000	-177.536	1.497	-176.039
41	-6500.000	7800.000	-178.730	1.274	-177.456
42	-6500.000	5200.000	-180.678	1.376	-179.302
43	-10400.000	9100.000	-177.641	1.489	-176.152
44	-11700.000	7800.000	-178.470	1.581	-176.889
45	-13000.000	6500.000	-179.210	1.457	-177.753
46	-11700.000	6500.000	-178.736	1.582	-177.154
47	-10400.000	7800.000	-178.203	1.457	-176.746
48	-16900.000	5200.000	-180.811	1.780	-179.031

49	-13000.000	-2600.000	-185.451	2.074	-183.377
50	-13000.000	0.000	-182.927	2.051	-180.876
51	-15600.000	0.000	-182.327	1.770	-180.557
52	-15600.000	2600.000	-182.137	1.690	-180.447
53	-14300.000	-1300.000	-183.443	1.993	-181.450
54	-13000.000	1300.000	-182.102	1.724	-180.378
55	-11700.000	3900.000	-179.036	1.683	-177.353
56	-13000.000	3900.000	-180.056	1.552	-178.504
57	-19500.000	6500.000	-179.568	1.422	-178.146
58	-15600.000	7800.000	-179.243	1.374	-177.869
59	-13000.000	9100.000	-178.969	1.375	-177.594
60	-19500.000	9100.000	-178.075	1.344	-176.731
61	-18200.000	7800.000	-178.797	1.325	-177.472
62	-15600.000	-11700.000	-190.746	2.520	-188.226
63	-10400.000	-10400.000	-190.994	2.652	-188.342
64	-9100.000	-9100.000	-190.158	2.677	-187.481
65	-11700.000	-6500.000	-187.876	2.495	-185.381
66	-11700.000	-5200.000	-188.417	2.465	-185.952
67	-10400.000	-2600.000	-186.883	3.350	-183.533
68	-7800.000	-2600.000	-186.919	2.219	-184.700
69	-5200.000	2600.000	-183.176	1.621	-181.555
70	-22100.000	6500.000	-179.876	1.386	-178.490
71	-24700.000	3900.000	-180.780	1.593	-179.187
72	-22100.000	3900.000	-180.728	1.523	-179.205
73	-24700.000	1300.000	-181.169	1.699	-179.470
74	-23400.000	-1300.000	-182.547	1.978	-180.569
75	-22100.000	0.000	-182.727	1.686	-181.041
76	-22100.000	1300.000	-182.061	1.630	-180.431
77	-19500.000	3900.000	-181.392	1.541	-179.851
78	-18200.000	2600.000	-182.084	1.569	-180.515
79	-18200.000	0.000	-182.347	1.765	-180.582
80	-20800.000	-1300.000	-183.293	1.841	-181.452
81	-16900.000	-2600.000	-181.625	2.026	-179.599
82	-19500.000	-6500.000	-183.207	2.371	-180.836
83	-20800.000	-9100.000	-184.580	2.517	-182.063
84	-15600.000	-7800.000	-186.147	2.339	-183.808
85	-14300.000	-6500.000	-186.674	2.459	-184.215
86	-16900.000	-6500.000	-183.885	2.611	-181.274
87	-15600.000	-5200.000	-183.950	2.240	-181.710
88	-18200.000	-5200.000	-182.073	2.554	-179.519
89	-14300.000	-3900.000	-184.786	3.301	-181.485
90	-19500.000	-2600.000	-182.890	2.436	-180.454
91	-22100.000	-6500.000	-184.401	2.339	-182.062
92	-24700.000	-5200.000	-183.648	2.163	-181.485
93	-19500.000	-10400.000	-185.795	2.563	-183.232
94	-16900.000	-9100.000	-186.793	3.009	-183.784
95	-13000.000	-6500.000	-188.285	2.414	-185.871
96	-5200.000	3900.000	-183.135	1.513	-181.622
97	-6500.000	3900.000	-182.007	1.466	-180.541
98	-3900.000	3900.000	-183.893	1.575	-182.318
99	-5200.000	5200.000	-182.000	1.415	-180.585
100	-7800.000	3900.000	-180.650	1.478	-179.172
101	-14300.000	-7800.000	-187.609	2.668	-184.941
102	-13000.000	-7800.000	-189.095	2.512	-186.583
103	-13000.000	-9100.000	-190.032	2.499	-187.533

104	-11700.000	-7800.000	-189.516	2.594	-186.922
105	-22100.000	-3900.000	-184.218	2.002	-182.217
106	-24700.000	-2600.000	182.291	1.945	-180.346
107	-28600.000	-1300.000	-176.897	1.969	-174.928
108	-29900.000	3900.000	-178.323	1.663	-176.660
109	-36400.000	3900.000	-171.860	1.849	-170.011
110	-32500.000	0.000	-174.660	1.926	-172.734
111	-31200.000	-3900.000	-175.593	2.242	-173.351
112	-28600.000	-7800.000	-179.205	2.296	-176.909
113	-28600.000	-5200.000	-178.320	2.225	-176.095
114	-31200.000	-6500.000	-175.238	2.263	-172.975
115	-22100.000	-10400.000	-182.849	2.534	-180.315
116	-24700.000	9100.000	-179.963	1.400	-178.563
117	-29900.000	7800.000	-179.422	1.576	-177.847
118	-9100.000	-13000.000	-191.397	3.201	-188.196
119	-11700.000	-13000.000	-191.148	2.773	-188.375
120	-11700.000	-10400.000	-190.984	2.629	-188.355
121	-6500.000	-7800.000	-190.002	2.874	-187.128
122	-1340.000	128.000	-185.088	2.024	-183.064
123	-38932.000	-4030.000	-171.475	2.101	-169.374
124	-41120.000	-8080.000	-172.280	2.169	-170.111
125	-46540.000	-7410.000	-168.052	2.444	-165.608
126	-46260.000	-964.000	-167.801	2.423	-165.378
127	-36608.000	10776.000	-174.862	1.842	-173.020
128	-40300.000	5200.000	-169.238	1.924	-167.314
129	-42511.000	-15334.000	-173.713	3.200	-170.513
130	-28600.000	-14300.000	-181.290	2.969	-178.321
131	-11700.000	0.000	-183.093	1.937	-181.156
132	-10400.000	5200.000	-177.896	1.510	-176.386
133	-9100.000	5200.000	-178.078	1.419	-176.660
134	-13000.000	5200.000	-179.326	1.465	-177.861
135	-14300.000	5200.000	-180.156	1.466	-178.690
136	-15600.000	5200.000	-180.550	1.443	-179.107
137	-10400.000	1300.000	-182.258	1.860	-180.398
138	-14300.000	3900.000	-180.875	1.521	-179.354
139	-5312.000	0.000	-184.782	1.859	-182.923
140	-3660.000	1300.000	-183.852	1.778	-182.074
141	-4604.000	-1117.000	-185.042	2.046	-182.996
142	-6223.000	-2454.000	-186.722	2.184	-184.538
143	-3084.000	-2704.000	-185.317	2.772	-182.545
144	-31200.000	-9100.000	-176.413	2.336	-174.077
145	-35655.000	-9696.000	-174.111	2.198	-171.913
146	-26000.000	-11700.000	-182.216	2.607	-179.609
147	-27300.000	-11700.000	-182.195	2.592	-179.603
148	-24700.000	-13000.000	-181.517	2.754	-178.763
149	-24700.000	-14300.000	-182.511	2.830	-179.681
150	-32177.000	-11879.000	-178.603	2.400	-176.203
151	-32262.000	6336.000	-176.516	1.608	-174.908
152	-34355.000	-1568.000	-173.899	2.050	-171.849
153	-18886.000	-15115.000	-185.424	2.861	-182.563

D-3 Refraction and Resistivity Surveys

D-3.1 Introduction

D-3.1.1 Purpose of Survey

Geophysical techniques were used in support of the subsurface hydrological investigation at the U.S. Army Depot near Tooele, Utah. The purpose of the investigation was to determine whether ground water contamination has occurred, and the potential for subsurface migration of contaminants. There were three objectives of the seismic refraction/electrical resistivity survey.

1. Determine subsurface structure south of the northern rock outcrop.
2. Determine if geophysical investigations can be used in the same area of TEAD to gather hydrologic information.
3. Provide a constraint for the interpretation of a gravity survey.

D-3.1.2 Survey Techniques

Three geophysical techniques; gravity, seismic refraction, and electrical resistivity, were used to delineate the subsurface structural features which may affect ground-water movement. A generalized basement-rock model of the valley was derived from a gravity survey conducted at the site. A description of the gravity survey can be found elsewhere in this report.

A seismic refraction survey was completed in the vicinity of the northern rock outcrop on the east side of the depot. The results of this survey were used to calibrate the gravity basement model and to confirm the existence of a shallow bedrock ridge that extends south from the outcrop. Such a ridge could restrict or alter the southeasterly flow of ground-water that has been inferred for the regional hydrogeologic system.

The refraction technique can delineate subsurface structure where an appropriate seismic velocity contrast exists. The technique measures the time required for a seismic wave to travel from a point of generation through the ground to detectors located on the surface. Wave arrival times are used to calculate the seismic velocities in the various media. Geologic stratigraphy and structure can be inferred by analyzing these velocities.

Electrical resistivity soundings were conducted at various locations along the refraction lines. This technique can delineate strata which have a resistivity contrast with the surrounding material. The method has been frequently useful in mapping ground-water aquifers because concentration and mobility of charged particles are the primary factors determining a material's resistivity.

A resistivity measurement is made in the following manner. A known current is forced to flow between two current electrodes which are in contact with the ground. This establishes an electric field in the earth. The distribution of the field depends on the resistivities and thicknesses of the various subsurface layers. The electric field is observed on the surface by measuring the potential difference across two potential electrodes. For this study, the potential electrodes are placed between, and in-line with, the current electrodes. One-dimensional, cross sections showing the distribution of resistivity layers with depth can be inferred from the measurements.

Significant ground-water in alluvium can usually be observed by both the seismic refraction and electrical resistivity techniques. The seismic compressional wave velocity in fine-grained materials such as sand or clay is generally less than about 3000 feet/second (fps) (915 meters/second [mps]) when it is dry, but the velocity is between 4800 and 5500 fps (1463-1676 mps) when it is saturated. Saturated zones interpreted from seismic results should be correlated with other data because several dry earth materials also have characteristic velocities within this range.

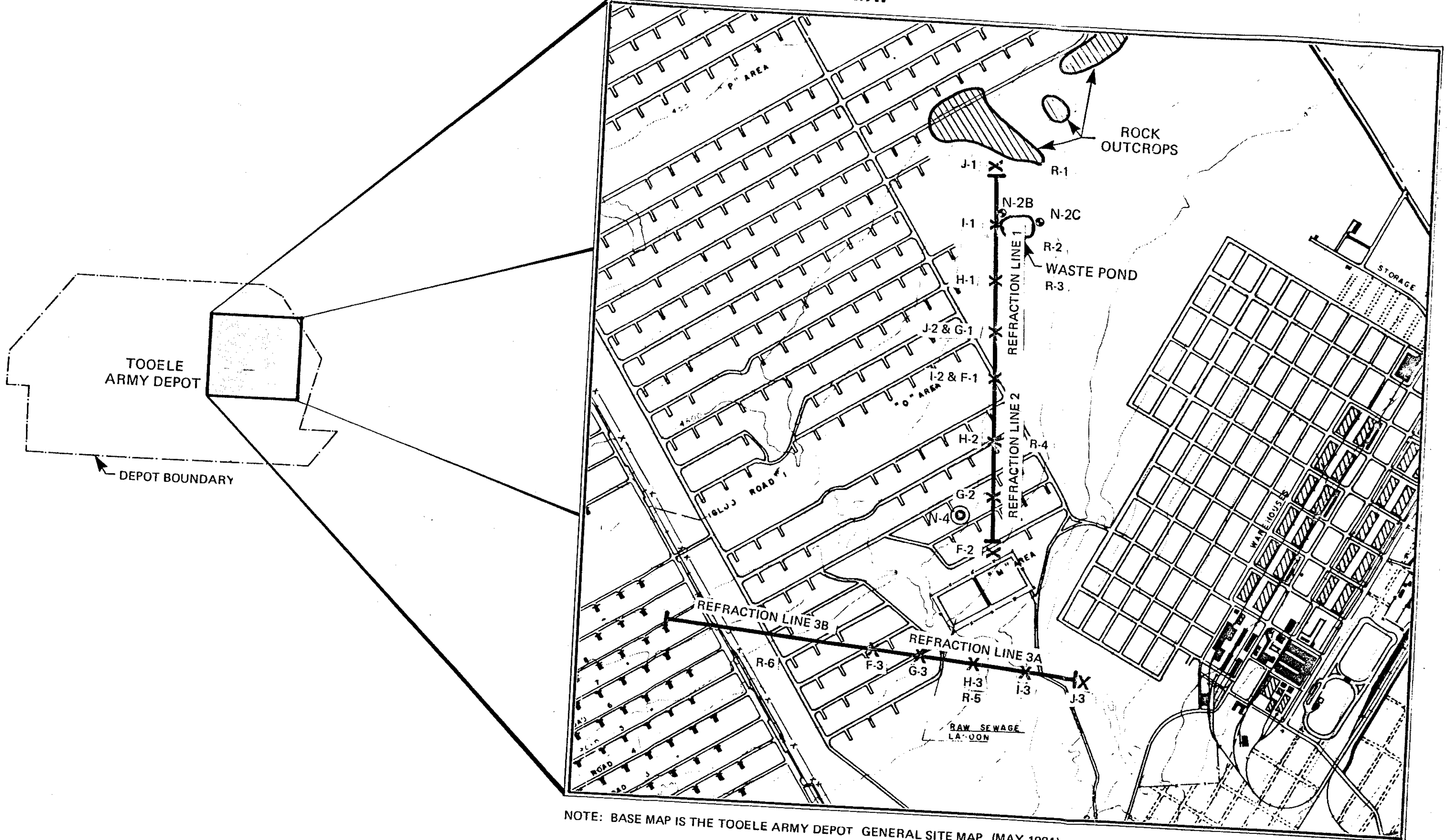
Ground-water is usually slightly saline and normally appears as a low resistivity zone in the sounding results. A subsurface zone with a seismic velocity between 4800 and 5500 fps (1463-1676 mps) and a low resistivity value could be logically interpreted as being a saturated zone.

D-3.1.3 Scope of Work

The seismic refraction survey is composed of four long lines as shown in Figure 1. The electrical resistivity survey consisted of six soundings which were conducted along the refraction lines. The survey was designed to collect information concerning the following questions:

1. Is the outcrop rock an isolated body or part of a more massive rock block?
2. If the outcrop is part of a larger rock mass, what is the depth and shape of the bedrock surface?
3. What is the velocity layering sequence in the overburden material?
4. Are there any geologic structures or unconformities in the section?
5. Are water saturated zones indicated?

The two north-south lines were positioned to map the buried rock ridge and the overburden material and the two east-west lines were positioned to investigate the lateral continuity of the section.



NOTE: BASE MAP IS THE TOOELE ARMY DEPOT GENERAL SITE MAP (MAY 1981)

0 1600 3200 FEET

SCALE 1:19,200

EXPLANATION

R-1 ELECTRICAL RESISTIVITY SOUNDINGS

G-3 SHOT POINTS

Ertec
The Earth Technology Corporation

PROJECT NO.: 82-160

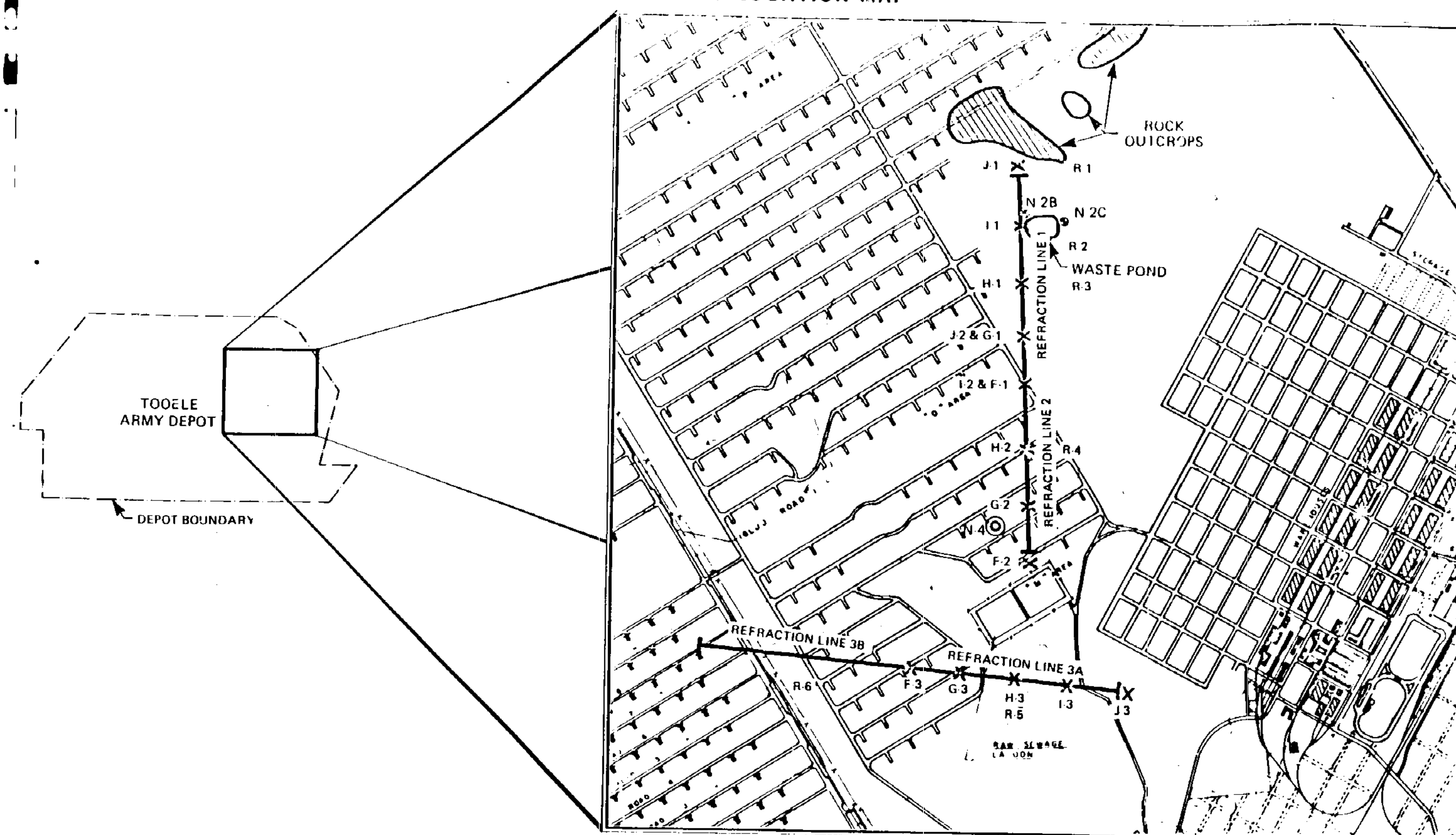
TOOELE ARMY DEPOT

REFRACTION AND RESISTIVITY
ACTIVITY LOCATION MAP
TOOELE, UTAH

6-82

Figure 1

ACTIVITY LOCATION MAP



NOTE: BASE MAP IS THE TOOELE ARMY DEPOT GENERAL SITE MAP (MAY 1981)

0 1600 3200 FEET

SCALE 1:19,200

EXPLANATION

R-1 ELECTRICAL RESISTIVITY SOUNDINGS

G-3 SHOT POINTS

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TOOELE ARMY DEPOT

REFRACTION AND RESISTIVITY
ACTIVITY LOCATION MAP
TOOELE, UTAH

The desired depth of penetration of a refraction survey dictates the geophone spacing and the type of energy source used. The refraction lines were designed to penetrate about 600 feet, which was the approximate depths to bedrock estimated from examining existing wells logs and outcrops. Explosives were used to generate the seismic energy.

D-3.2 Seismic Refraction Survey

D-3.2.1 Recording Instruments

Seismic data were recorded with a 24-channel SIE Model RS-44 seismograph. The system processes 24 channels of seismic signals and produces a hard copy with a dry-write, galvanometer type recording oscillograph. The degree of gain was set on the system amplifiers by the instrument operator and was limited by the background noise at the time of the shot. Full width timing lines are impressed onto the record at 10 millisecond intervals. The timing lines are used to measure the time taken by the seismic wave to travel from the point of generation (shot point) to the geophones.

Mark Products Model L-10 geophones with a natural frequency of 4.5 Hz were used. They were fitted with short spikes to provide good coupling with the ground. Cables with connectors at 150-foot (46 m) intervals were used to transmit the signal from the geophones to the recording system.

D-3.2.2 Seismic Energy Generation

Seismic energy was generated by an explosive impulse. Small charges were placed in shallow borings at shot points along the refraction line. The charges were detonated one at a time and the resulting shock wave was measured by surface detectors as it traveled through the ground. The safe and controlled use of explosives is essential in gathering refraction data. The U.S. Army required Ertec Western to demonstrate that proper safety procedures would be followed when handling explosive materials and to estimate the effect of vibrations produced by the explosions which would be used in the refraction survey.

In satisfying these requirements, the U.S. Army approved Ertec Western's "Standing Operating Procedures" for explosive use, then we conducted a blast vibration monitor program at the depot. A report (Ertec Western, 1982) was submitted describing the testing procedures and the recorded vibration levels. The approved procedures were followed during the refraction survey.

D-3.2.3 Refraction Data Acquisition

The field work was performed between January 8 and February 10, 1982. Each of the four refraction lines were about 3450 feet (1052 m) long and contained 24 geophones and five shot points as shown in Figure 1.

The geophone intervals and shot point locations were determined by the location of the connectors on the cables. Relative elevations of the geophones and shot points were measured with a transit and tied to true elevations on the existing grid at the depot. Geophones were placed and covered in shallow (less than 1 foot [0.3 m]) hand-excavated holes in order to improve energy coupling with the ground and to reduce extraneous wind noise. This procedure permitted the instrument operator to increase the amplification level in the recording system.

All shot points on a refraction line were drilled, loaded with explosives and backfilled before the recording began. One shot was denotated at a time and a record was made of the event. The time of shot was transmitted from the shot point to the recording system via an FM radio link.

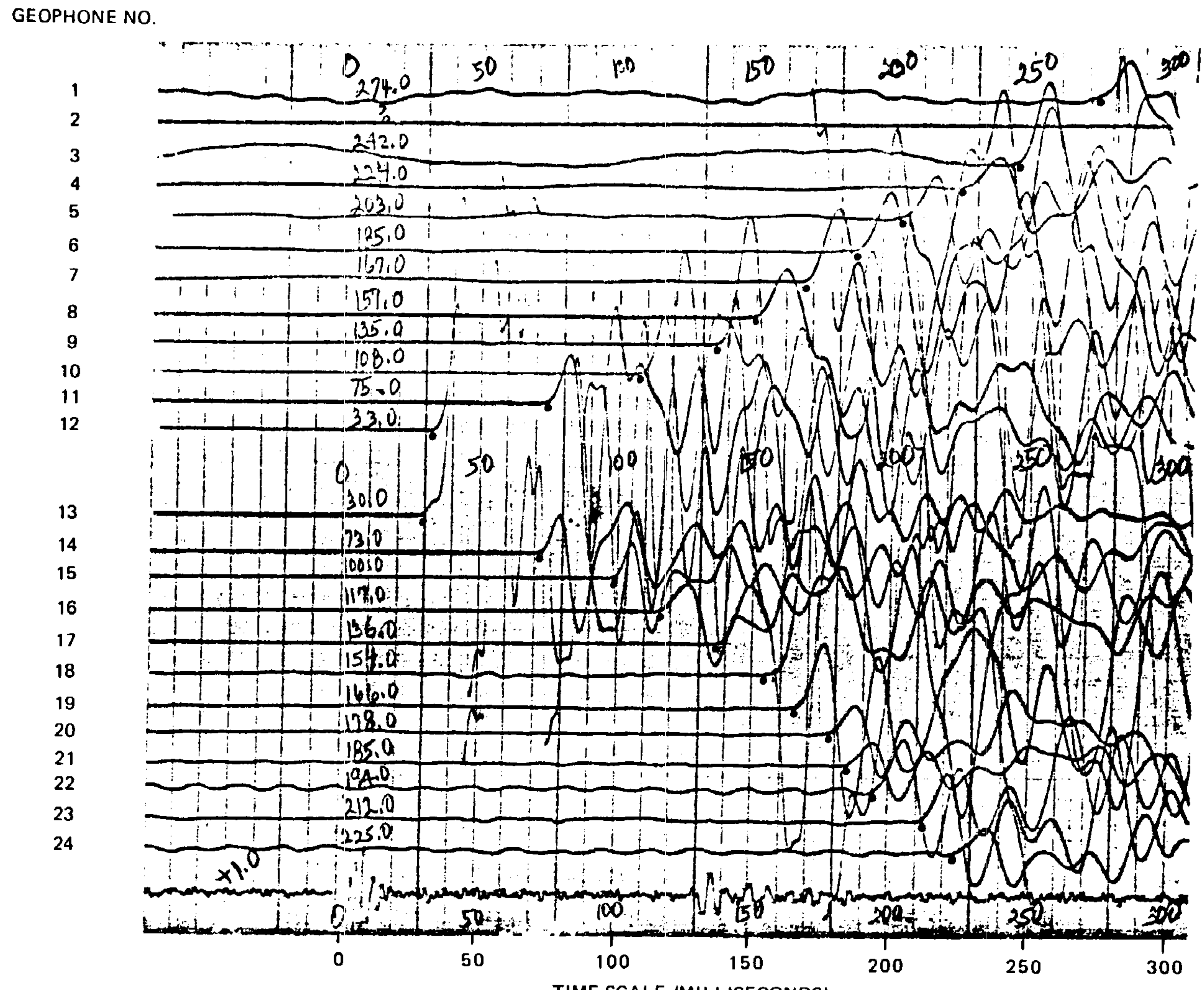
D-3.2.4 Refraction Data Reduction

The refraction records were analyzed to determine the time interval between the explosive detonation and the arrival of the compressional (P) wave at each geophone. A typical refraction seismogram is shown in Figure 2. The P wave arrival usually appeared as a rather obvious excursion of the recording trace from its rest position. First, the compressional wave arrival at each geophone was identified on the record and then the travel times were measured. These times and the array geometry for each line are shown in Figures 3 and 4.

The upper halves of these figures are graphs of seismic wave travel times plotted versus surface distance between the shot points and the geophones. Distances were measured along the north-south line from geophone number 1, of line 2 and along the east-west line from geophone 1 of line 3B. Distances to the right of the first geophone are positive. The direction arrow gives the approximate orientation of the line from the first geophone toward the other end of the line. The vertical lines designate the locations of shot points (F, G, H, I, J). The symbol X denotes travel times at geophones that were to the right of a shot point. The symbol 0 denotes travel times to geophones that were to the left of a shot point.

The Generalized Reciprocal Method (GRM) of seismic refraction interpretation (Palmer, 1980) was used to analyze these graphs and to calculate the velocity profile beneath each line. Computer programs SEISSF and DSECTN (Hatherly, 1978) were used to calculate the various functions of the GRM. The GRM combines the computational ease of the reciprocal method (Hawkins, 1961) with the migration property of the delay time method (Gardner, 1939).

Com_____ Drawn by _____ ed by _____ Approved by _____



SEISMOGRAM RECORDED WITH SIE MODEL RS-44 SEISMOGRAPH. RECORD WAS TAKEN AT LINE 2, SHOT POINT H.

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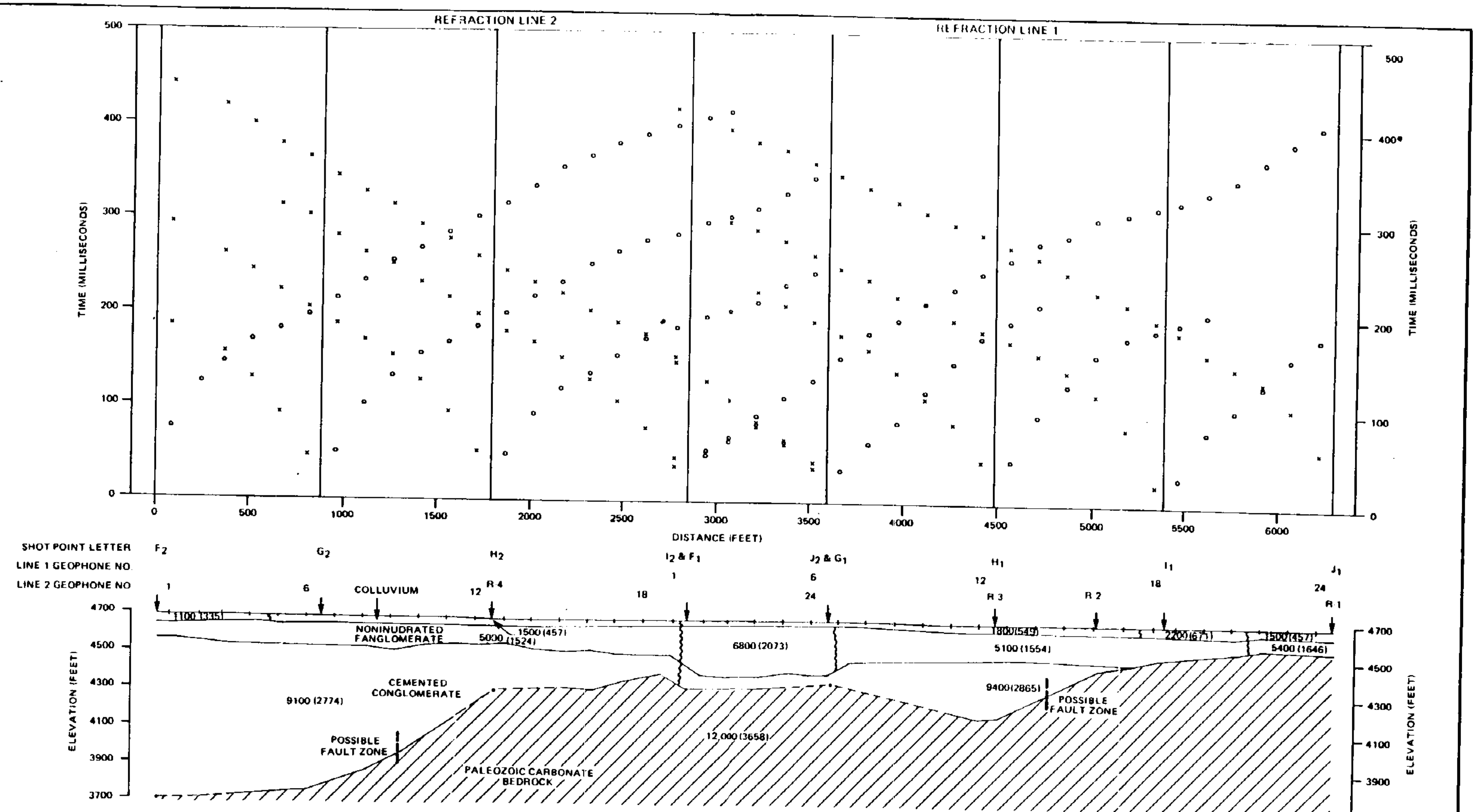
TYPICAL REFRACTION RECORD

8-82

FIGURE 2



EXPLANATION

- × TIMES TO THE RIGHT OF SHOT
- o TIMES TO THE LEFT OF SHOT
- 8100 SEISMIC VELOCITY IN FEET/SECOND (METERS/SECOND)
- • CALCULATED DEPTH POINTS
- --- INTERFACES DASHED WHEN PROJECTED
- R-1 ELECTRICAL RESISTIVITY SOUNDING LOCATION

NORTH

NOTE: ROCK OUTCROP APPROXIMATELY 300 FEET (91m) TO THE NORTH OF SHOT POINT J_1

METERS
0 100 200
DISTANCE AND DEPTH

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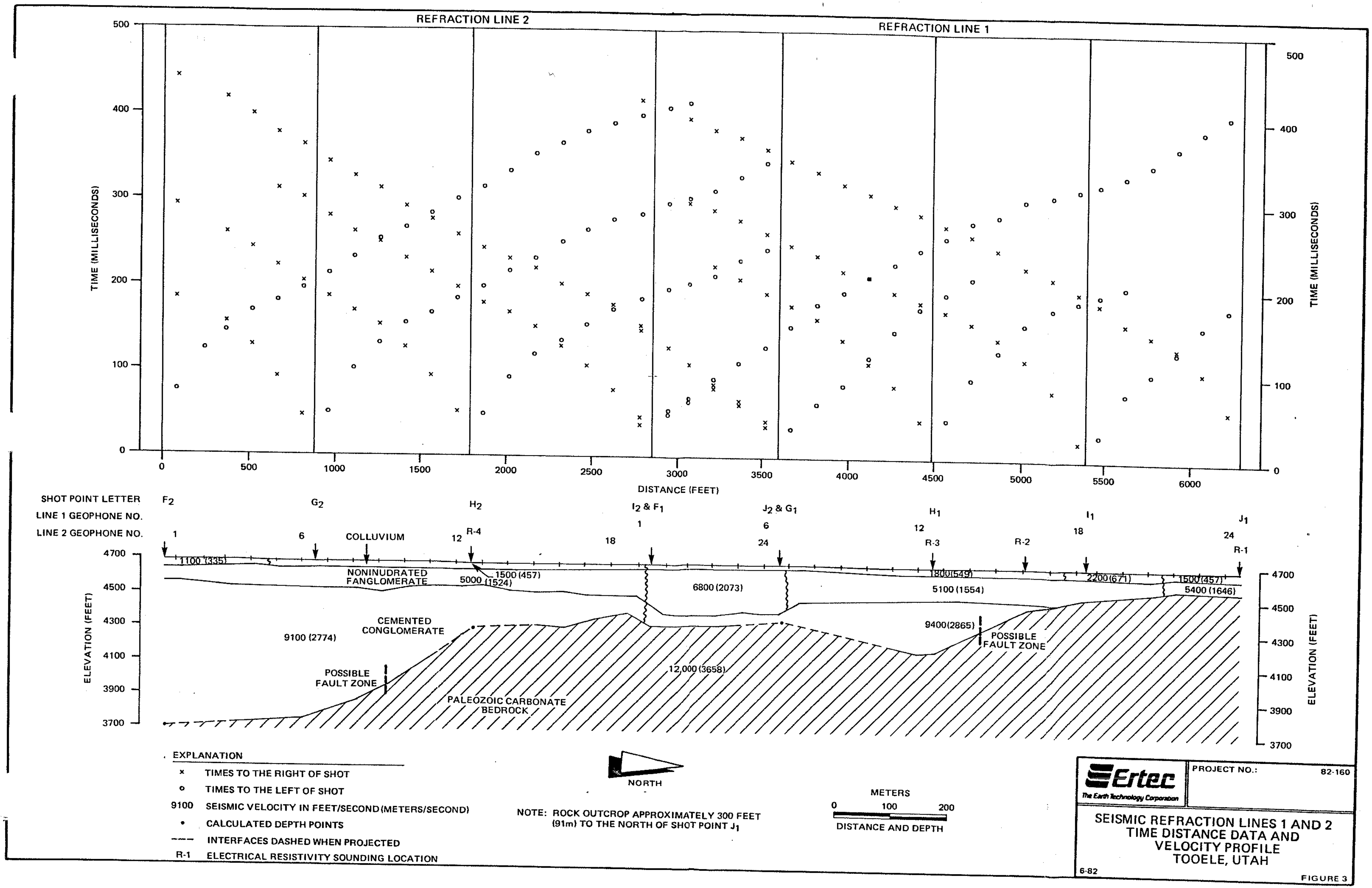
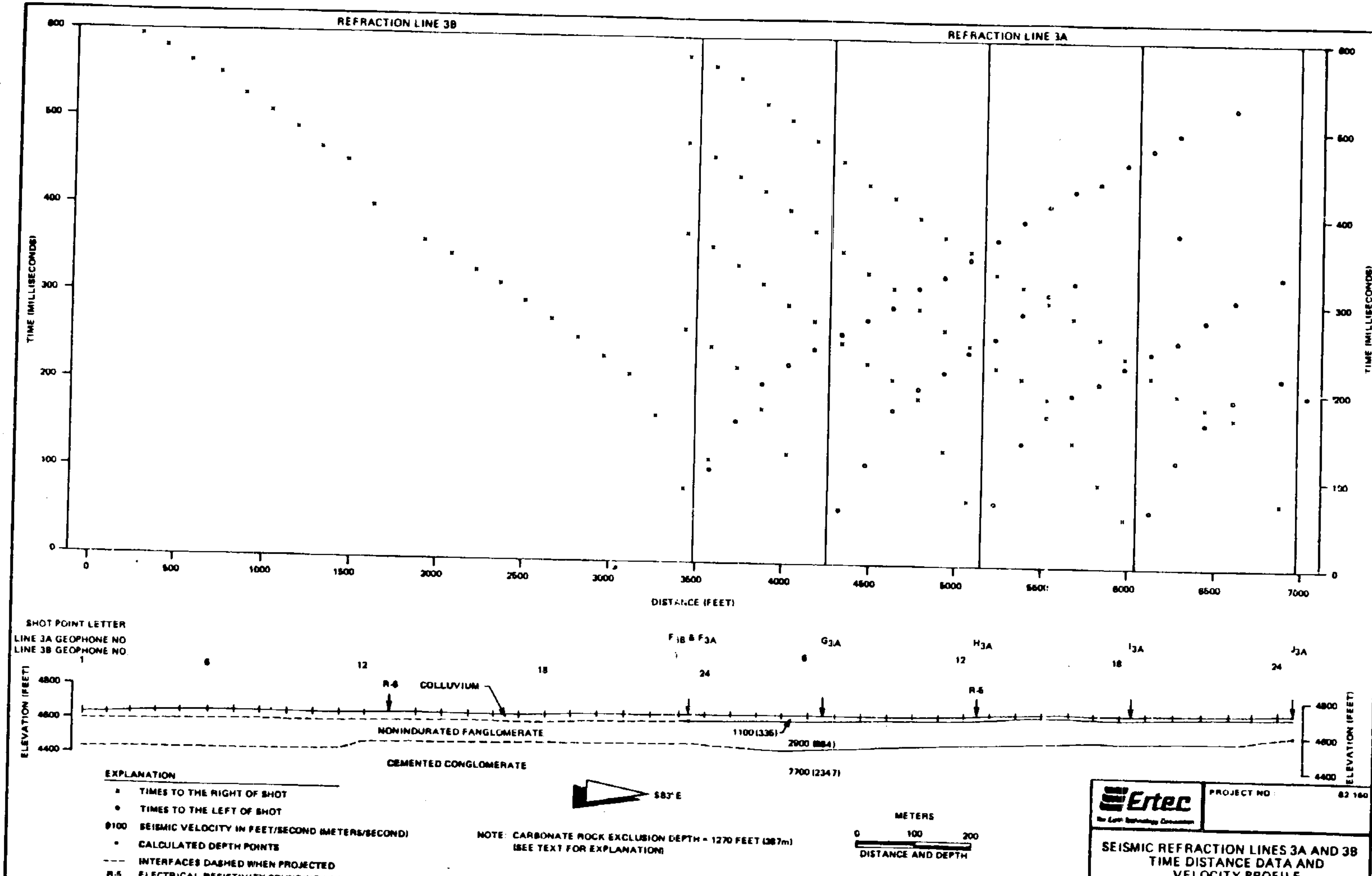
SEISMIC REFRACTION LINES 1 AND 2
TIME DISTANCE DATA AND
VELOCITY PROFILE
TOOELE, UTAH

6 82

FIGURE 3



REFRACTION LINE 2
REFRACTION LINE 1
TIME (MILLISECONDS)
DISTANCE (FEET)
SHOT POINT LETTER
LINE 1 GEOPHONE NO.
LINE 2 GEOPHONE NO.
F_2
G_2
H_2
I_2 & F_1
J_2 & G_1
H_1
I_1
J_1
COLLUVIUM
R-4
R-3
R-2
R-1
ELEVATION (FEET)
1100 (335)
NONINUDRATED FANGLOMERATE
5000 (1524)
1500 (457)
6800 (2073)
1800 (549)
5100 (1554)
2200 (671)
1500 (457)
5400 (1646)
CEMENTED CONGLOMERATE
9100 (2774)
9400 (2865)
POSSIBLE FAULT ZONE
POSSIBLE FAULT ZONE
12,000 (3658)
PALEOZOIC CARBONATE BEDROCK
EXPLANATION
× TIMES TO THE RIGHT OF SHOT
o TIMES TO THE LEFT OF SHOT
9100 SEISMIC VELOCITY IN FEET/SECOND (METERS/SECOND)
• CALCULATED DEPTH POINTS
--- INTERFACES DASHED WHEN PROJECTED
R-1 ELECTRICAL RESISTIVITY SOUNDING LOCATION
NORTH
NOTE: ROCK OUTCROP APPROXIMATELY 300 FEET (91m) TO THE NORTH OF SHOT POINT J_1
METERS
0 100 200
DISTANCE AND DEPTH
Ertec
The Earth Technology Corporation
PROJECT NO.: 82-160
SEISMIC REFRACTION LINES 1 AND 2
TIME DISTANCE DATA AND
VELOCITY PROFILE
TOOELE, UTAH
6-82
FIGURE 3



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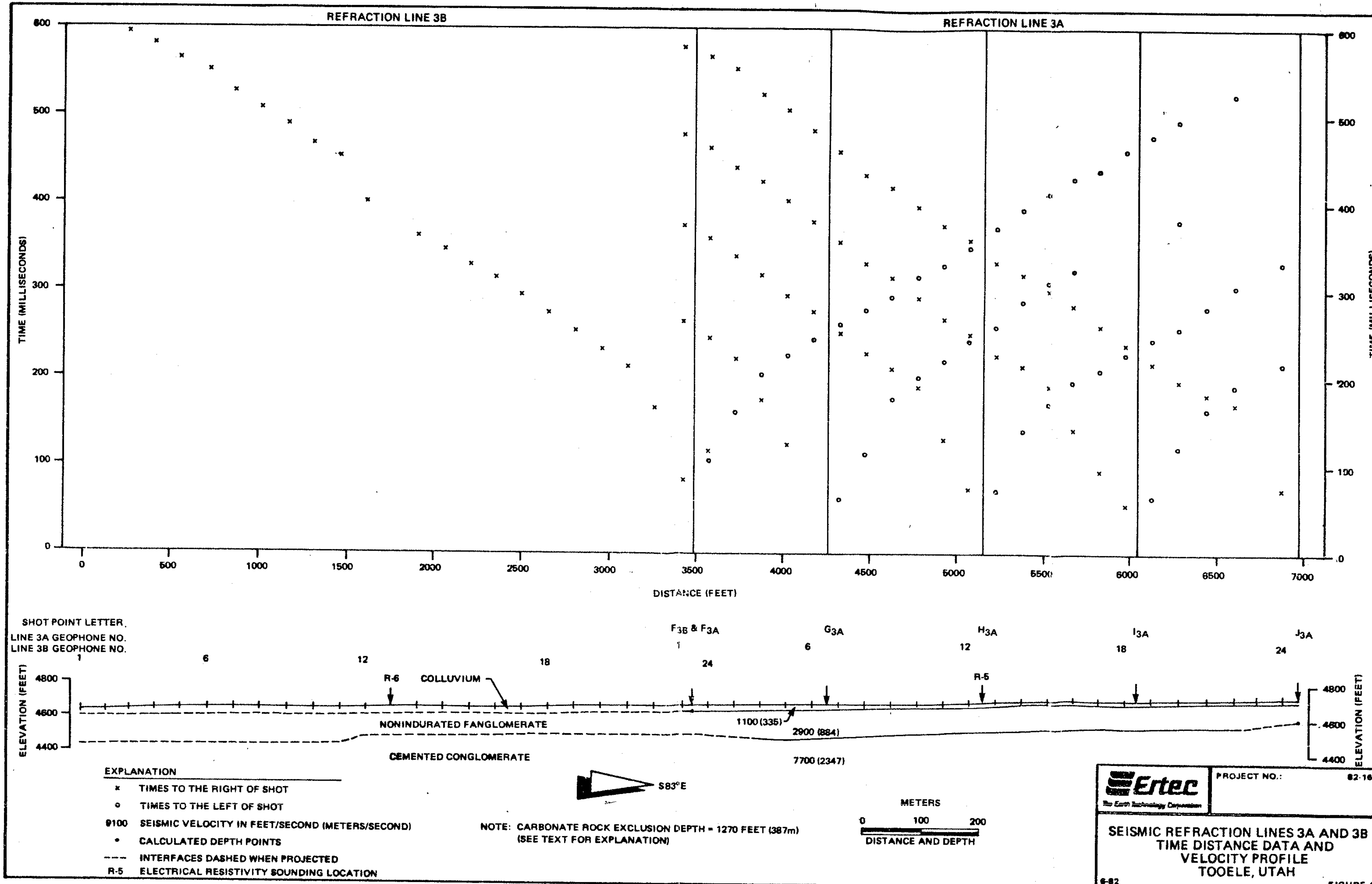
PROJECT NO.: 82 160

SEISMIC REFRACTION LINES 3A AND 3B
TIME DISTANCE DATA AND
VELOCITY PROFILE
TOOELE, UTAH

6-82

FIGURE 4



SEISMIC REFRACTION LINES 3A AND 3B TIME DISTANCE DATA AND VELOCITY PROFILE TOOELE, UTAH

FIGURE 4

The lower halves of Figures 3 and 4 show the interpreted seismic velocity profiles. The top lines represent the ground-surface profiles. The short vertical lines crossing the top line mark the geophone positions. The depth scales are plotted relative to true elevations from sea level. The additional lines across the cross section represent the interpreted boundaries between layers of material with different compressional wave velocities. The calculated P wave velocity is shown for each layer.

D-3.2.5 Refraction Results

A brief description of the refraction results for the north-south and east-west lines is given below. The correlation between velocities and lithologies is based on interpretations of boring logs obtained during the hydrologic investigation.

North-South Line (Figure 3)

1. The first layer (surface material) is a colluvium that has a very low average P wave velocity of 1600 fps (488 mps). The thickness of the layer varies between 25 and 50 feet (8 and 15 m). The measured velocities for this layer varied by 31 percent from 1100 to 2200 fps (335 to 671 mps).

2. The second layer is a nonindurated fanglomerate that has an average P wave velocity of 5150 fps (1570 mps). The velocity of this layer varies by 17 percent except for an anomaly, 6800 fps (2073 mps), in the center of the line. The top surface of the layer is fairly flat except near the velocity anomaly. The thickness ranges between 70 and 270 feet (21 and 82 m).

3. The third layer in the section is a cemented conglomerate that has a well defined, average P wave velocity of 9250 fps (2819 mps) which varied by ± 2 percent. This layer is 850 feet (259 m) thick on the south end of the line and pinches out just south of shot point I_1. The geometry of this layer is irregular.

4. The deepest velocity layer mapped by this line is a Paleozoic carbonate bedrock with a P wave velocity of 12,000 fps (3658 mps) which varied by ± 8 percent. The top surface of this layer is irregular.

East-West Line (Figure 4)

1. The colluvium, surface layer has a fairly well defined P wave velocity of 1100 fps (335 mps). This velocity varied ± 18 percent from 950 to 1300 fps (290 to 396 mps). The layer has an average thickness of 25 feet (8 m).

2. The second layer, fanglomerate, has an average P wave velocity of 2900 fps (884 mps) that varied by ± 10 percent. The surface of this layer is fairly flat with thicknesses ranging from 130 to 210 feet (40 to 64 m).

3. The deepest velocity layer mapped under this line is a cemented conglomerate that has an average P wave velocity of 7700 fps (2347 mps) that varied by ± 9 percent. The top surface of this layer is fairly flat. There is a 40-foot (12 m) step, in the calculated layer surface at line 3B, geophone 11.

4. The 12,000 fps (3658 mps) velocity associated with carbonate bedrock was not observed with the east-west lines. Therefore, the bedrock must be beyond the depth of penetration associated with the line geometry. This geometry would have detected the 12,000 fps (3658 mps) layer if it had been shallower than 1270 feet (387 m).

The P wave arrivals on the refraction records are good quality and are easily identified. The seismic velocities are estimated to be correct within ± 10 percent or less, except for the surface layer. Arrivals representing seismic waves traveling solely in the first layer are seldom observed at more than one geophone from any shot. Therefore, the accuracy of the first layer velocity determination is relatively low because they are based on so few data points.

D-3.3 ELECTRICAL RESISTIVITY SURVEY

D-3.3.1 Recording Instrument

The electrical resistivity data were measured with a Bison Model 2350A resistivity meter. Stainless steel rods were used for the current electrodes. Copper rods immersed in a saturated copper sulfate solution in a porous pot were used for the voltage measuring electrodes.

D-3.3.2 Resistivity Data Acquisition

The field data were collected between January 28 and February 18, 1982. Six soundings using the Schlumberaer electrode array were made. Their locations are shown in Figure 1. The geometry of this measurment array is shown in Figure 5. To make a sounding, the spacing between the electrodes is expanded between measurements, while the center of the array remains fixed. As the array expands, the current penetrates deeper into the earth, thus allowing the variation of resistivity with depth and material changes to be reflected in the surface measurements. Fourteen measurements were taken for each sounding, with the electrode separation (Figure 5) expanding from 15 to 350 feet (5 to 107 m).

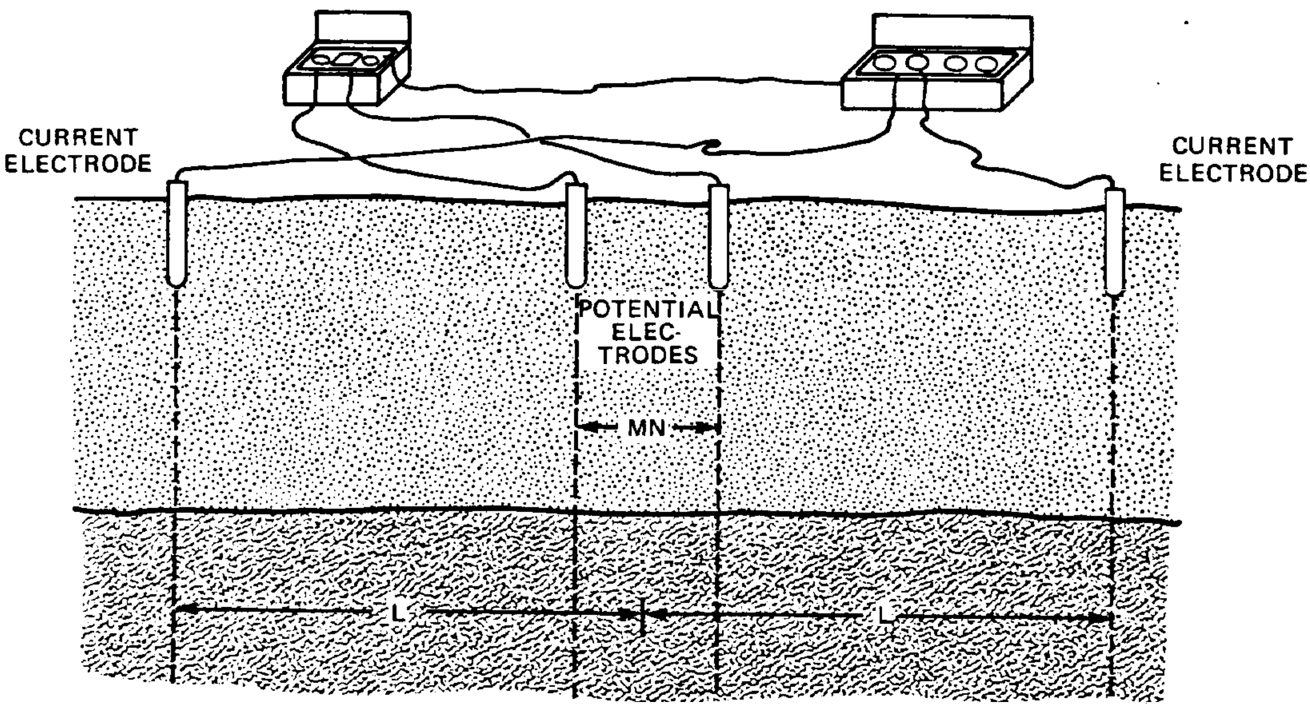
Apparent resistivity values were calculated from the measured values using the following equation:

$$= \frac{L^2}{MN} \quad \frac{V}{I} \text{(ohm meter)}$$

(See Figure 5 for definition of the various terms). The apparent resistivity was plotted versus the electrode separation and checked for bad points by the field crew before leaving the test site. The resistivity data appears in the upper half of Figures 6 through 11.

D-3.3.3 Resistivity Data Reduction

If the ground is electrically homogeneous, the measured resistivity values would represent the true soil resistivities. However, the ground is usually composed of several subsurface layers, each of which will alter the distribution of the applied electric field. Therefore, the surface measurements represent a composite resistivity value of the underlying strata. This composite resistivity is termed "apparent resistivity" and is not equal to true



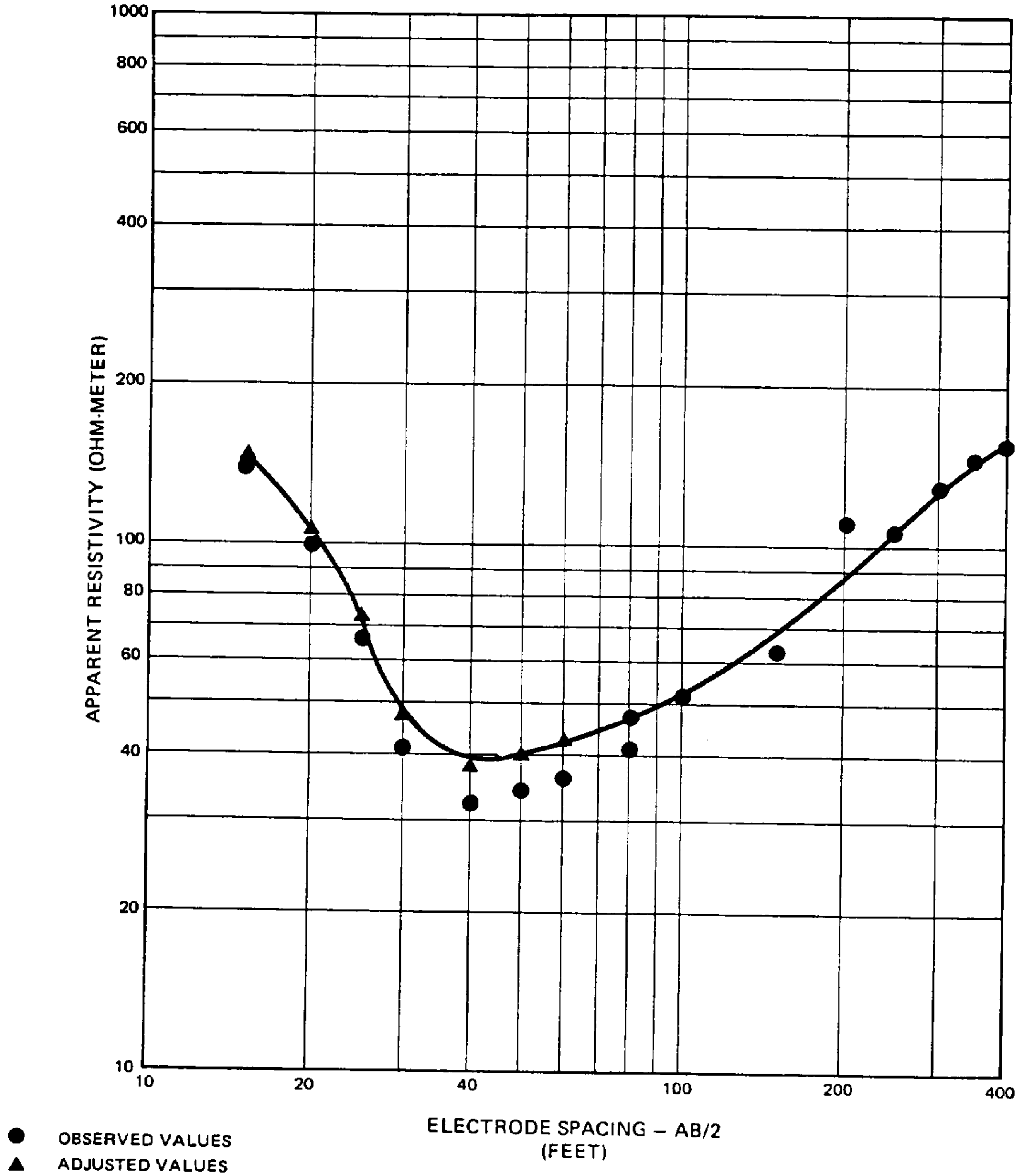
SCHLUMBERGER ARRAY

PROJECT NO.: 82-160

SCHLUMBERGER ELECTRODE ARRAY

6-82

FIGURE 5



INTERPRETED MODEL				
LAYER DEPTH			RESISTIVITY VALUES	
FEET	METERS	% DEVIATION	OHM-METER	% DEVIATION
0	0	–	310	11
7	2	5	30	5
59	18	11	460	28

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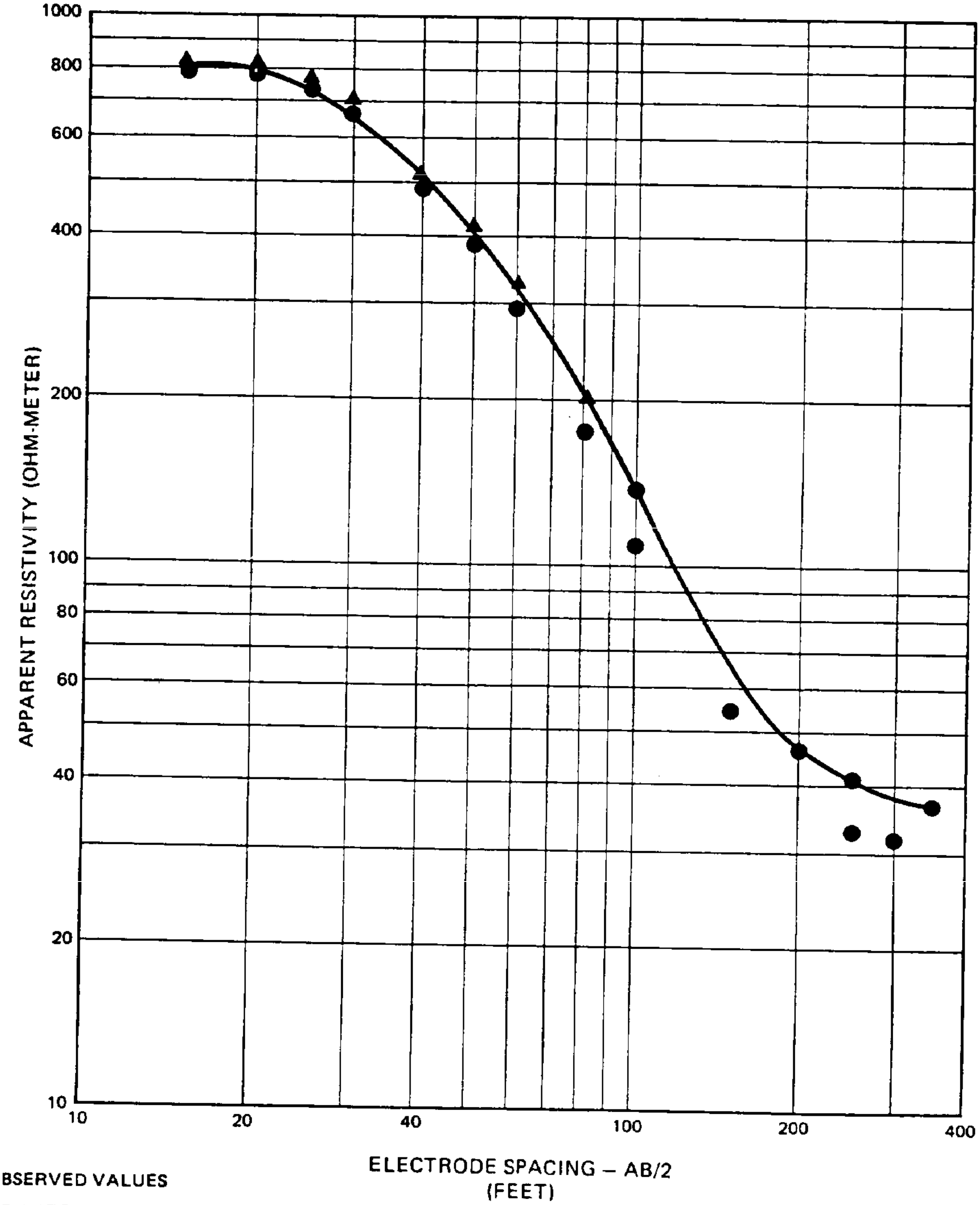
RESISTIVITY SOUNDING R-1
SOUNDING CURVE AND INTERPRETATION
TOOELE, UTAH

6-82

FIGURE 6



● OBSERVED VALUES

▲ ADJUSTED VALUES

INTERPRETED MODEL				
LAYER DEPTH			RESISTIVITY VALUES	
FEET	METERS	% DEVIATION	OHM-METER	% DEVIATION
0	0	–	720	4
31	9	3	40	5

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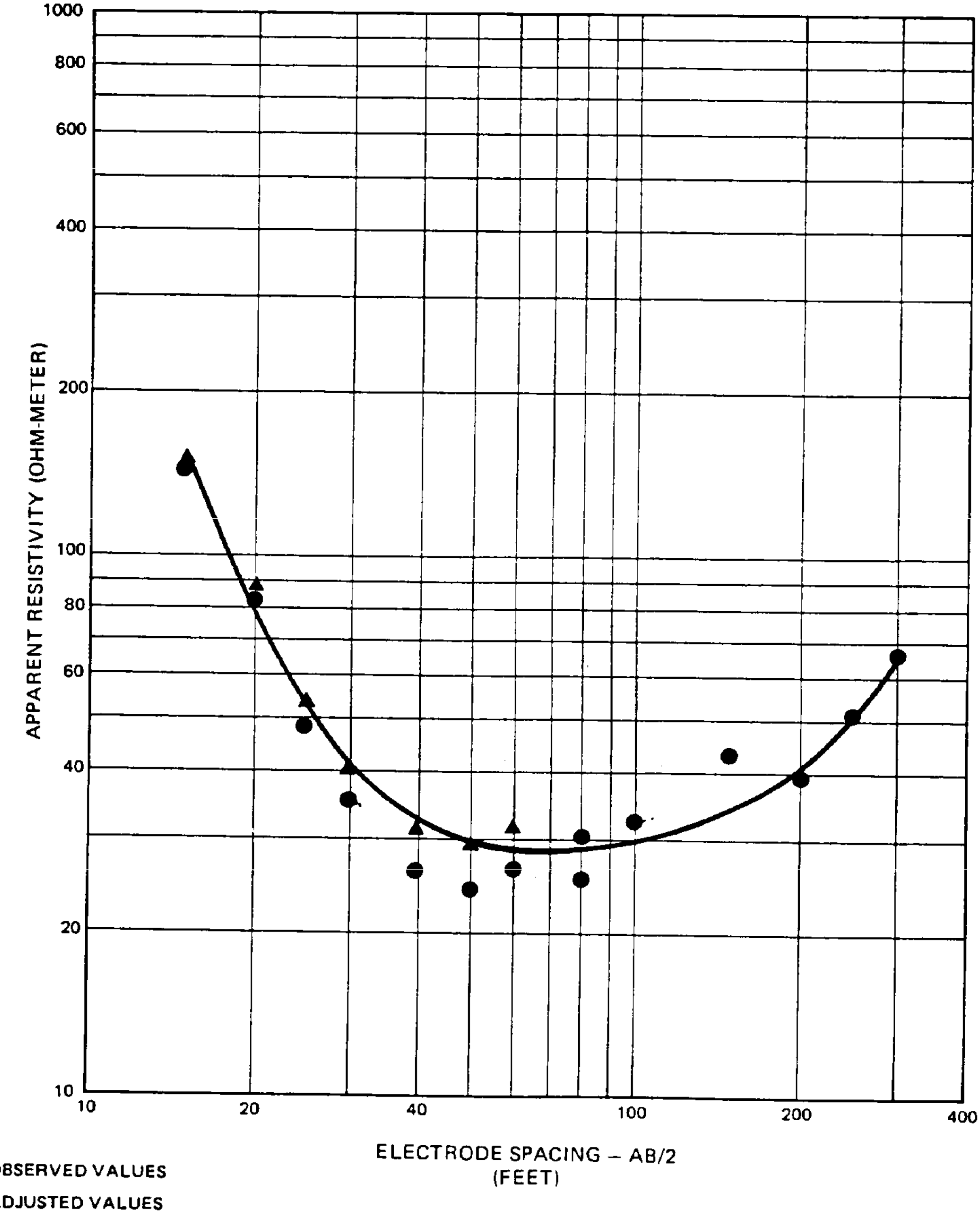
RESISTIVITY SOUNDING R-2
SOUNDING CURVE AND INTERPRETATION
TOOELE, UTAH

6-82

FIGURE 7



INTERPRETED MODEL				
LAYER DEPTH			RESISTIVITY VALUES	
FEET	METERS	% DEVIATION	OHM-METER	% DEVIATION
0	0	–	230	18
7	2	9	30	7
89	27	39	130	94

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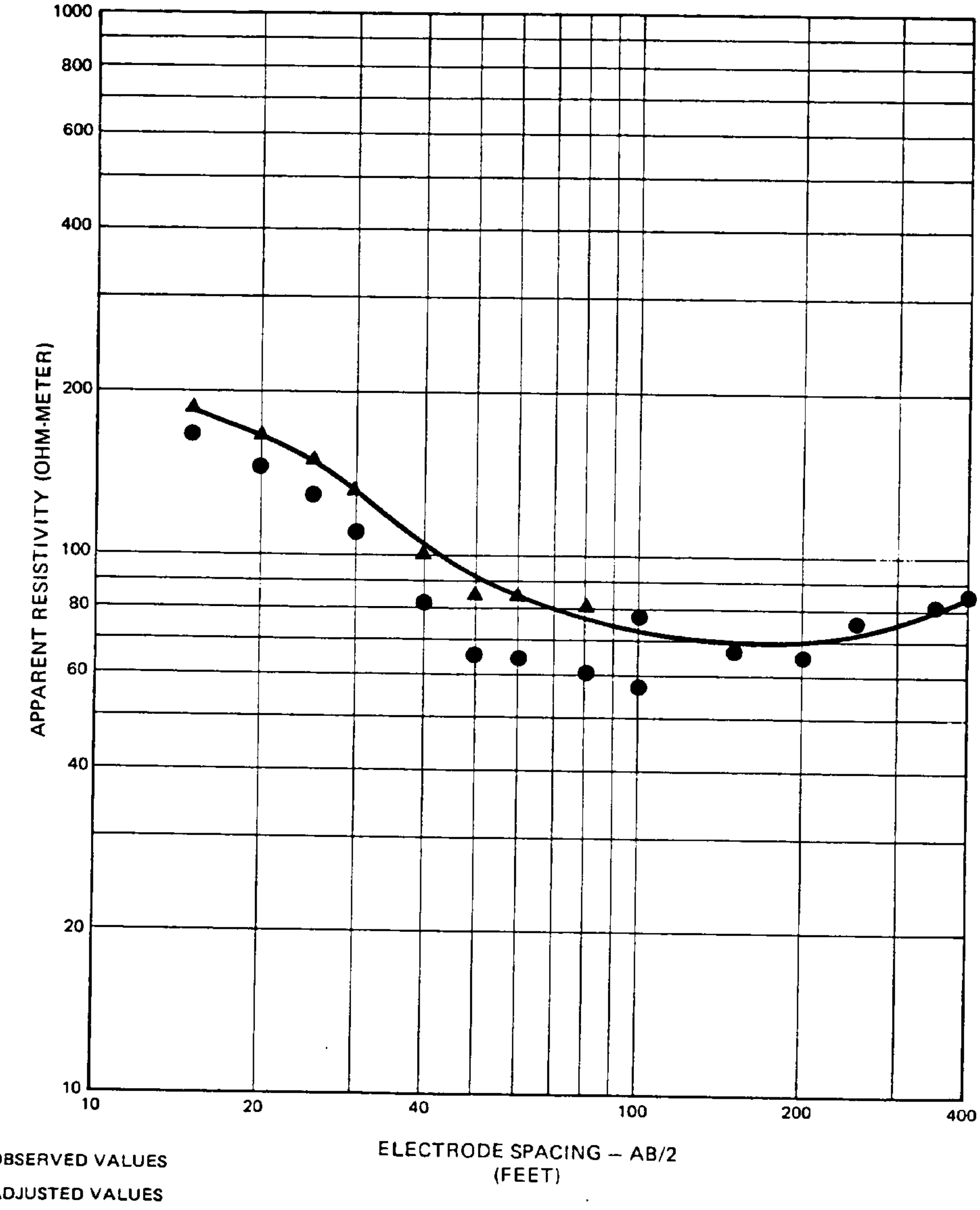
RESISTIVITY SOUNDING R-3
SOUNDING CURVE AND INTERPRETATION
TOOELE, UTAH

6-82

FIGURE 8



INTERPRETED MODEL				
LAYER DEPTH			RESISTIVITY VALUES	
FEET	METERS	% DEVIATION	OHM-METER	% DEVIATION
0	0	–	210	7
13	4	8	70	12

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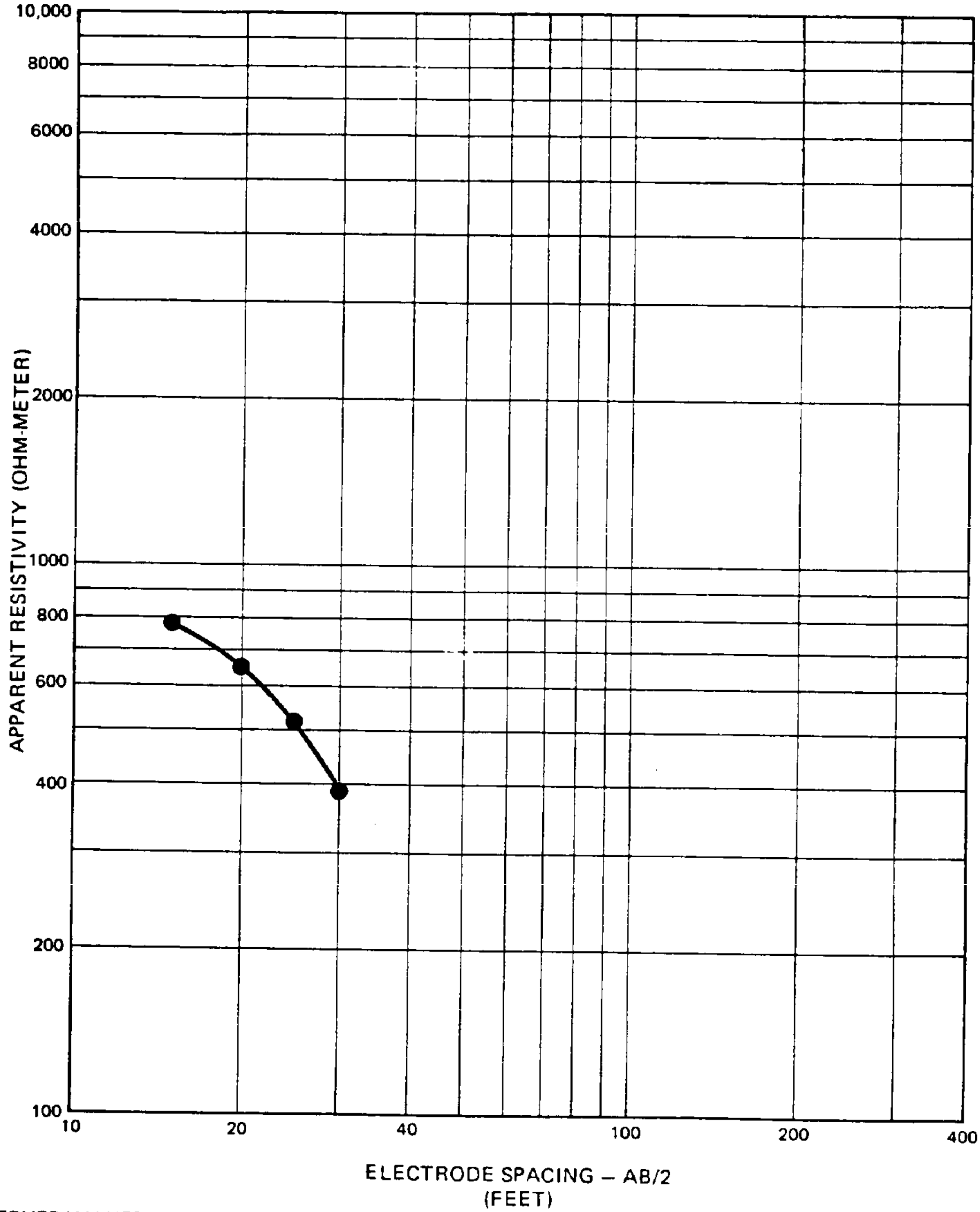
PROJECT NO.: 82-160

RESISTIVITY SOUNDING R-4
SOUNDING CURVE AND INTERPRETATION
TOOELE, UTAH

6-82

FIGURE 9



● OBSERVED VALUES

INTERPRETED MODEL				
LAYER DEPTH			RESISTIVITY VALUES	
FEET	METERS	% DEVIATION	OHM-METER	% DEVIATION
		NOT ENOUGH DATA TO MODEL		

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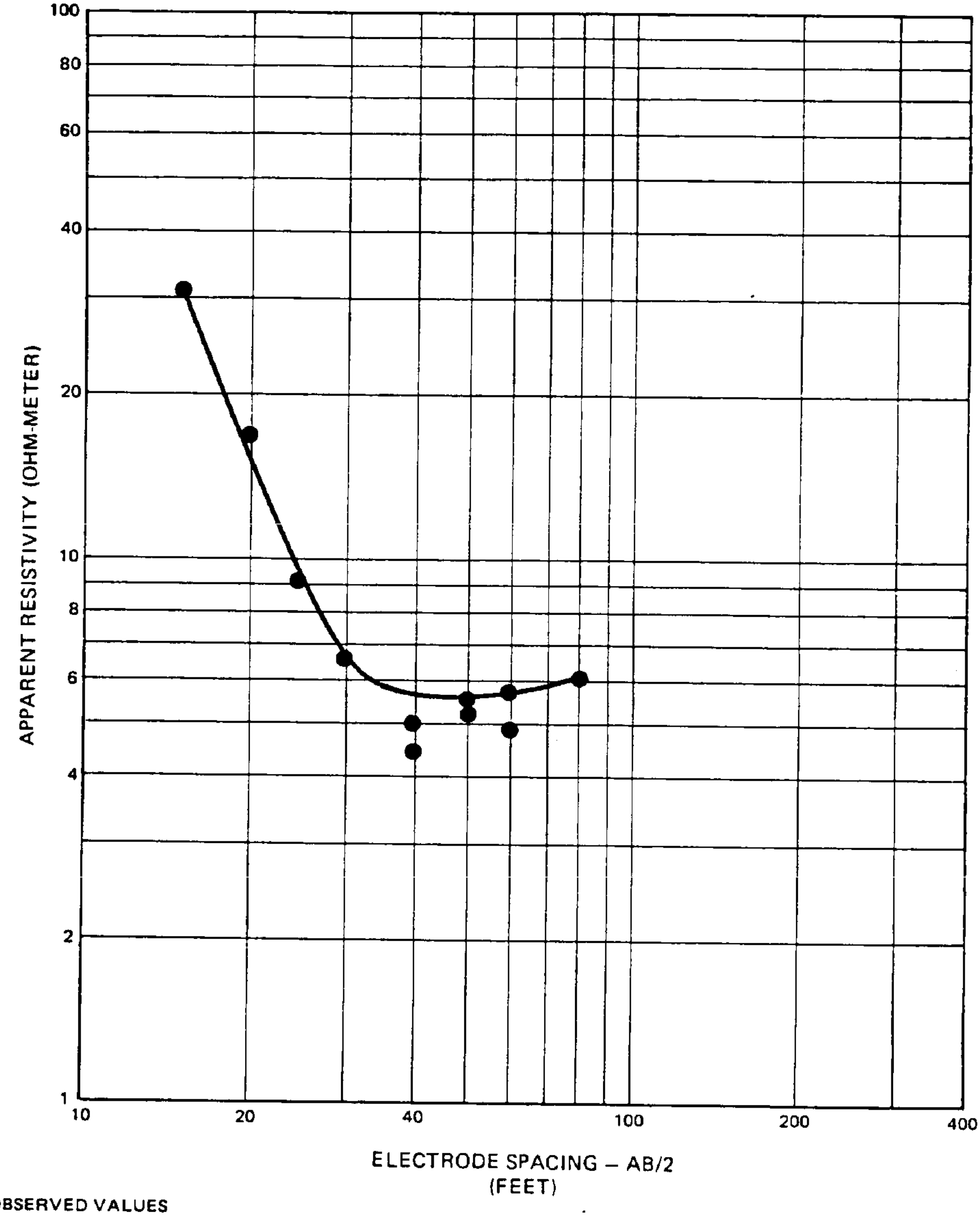
PROJECT NO.: 82-160

RESISTIVITY SOUNDING R-5
SOUNDING CURVE AND INTERPRETATION
TOOELE, UTAH

6 82

FIGURE 10



INTERPRETED MODEL				
LAYER DEPTH			RESISTIVITY VALUES	
FEET	METERS	% DEVIATION	OHM-METER	% DEVIATION
0	0	–	110	6
6	2	2	5	3
42	13	72	9	67

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PROJECT NO.: 82-160

RESISTIVITY SOUNDING R-6
SOUNDING CURVE AND INTERPRETATION
TOOELE, UTAH

6-82

FIGURE 11

soil resistivity. By making a number of measurements at a site, it is possible to convert an apparent resistivity field curve into a layered subsurface model with a calculated "true" resistivity for each layer of the model.

A resistivity field curve consists of several segments, each corresponding to a differend MN spacing. the vertical offset between two adjacent segments is caused by either one or both of the potential electrodes crossing a near surface, lateral interface into a material with a different resistivity value. These offsets must be removed prior to computer modeling because they represent a resistivity change due to lateral not depth effects. The segments were adjusted relative to the largest MN spacing used in the sounding. At this spacing, a large part of the electric field in the earth is being measured. This large measurement interval is not an influenced by small, localized, surface resistivity anomolies as smaller MN spacings. Consecutive segments (from large to small MN spacings) were vertically shifted until a smoothed curve was obtained. The curve was then digitized and used for computer input.

The resistivity data were interpreted with the aid of two inverse modeling computer programs. The program by Zhody (1973) uses modified Dar Zarrouk functions in an iterative process to determine true resistivity values of the various subsurface layers. The resulting model is then used as an initial estimate to Rijo's (1977) program. The program calculates theoretical resistivity values by convolution with a set of filter coefficients. Derivatives of the theoretical resistivity values with respect to the parameters are then calculated numerically and used in a Marquardt (ridge) regression algorithm to calculate improvements in the values of the parameters. This process is continued through a specified number of iterations or until the successive changes in the parameters is less than a preselected value.

The resulting geoelectric cross sections were evaluated versus the field curves and geologic knowledge of the area. The interpreted models are tabulated at the bottom of Figures 6 through 11.

D-3.3.4 Resistivity Results

The interpretation of the electrical resistivity survey is shown in cross sectional view in Figure 12. The four resistivity soundings along the north-south refraction line show the top of a low resistivity zone between 10 and 30 feet (3 and 9 m) deep. This low resistivity zone is in the fanglomerate material. Soundings R-1 and R-3 show this zone to be fairly thick, about 60 feet (18 m). The seismic velocity of this layer is between 5000 and 5400 fps (1524 and 1646 mps). Therefore this layer could be interpreted as being a saturated zone of varying thickness.

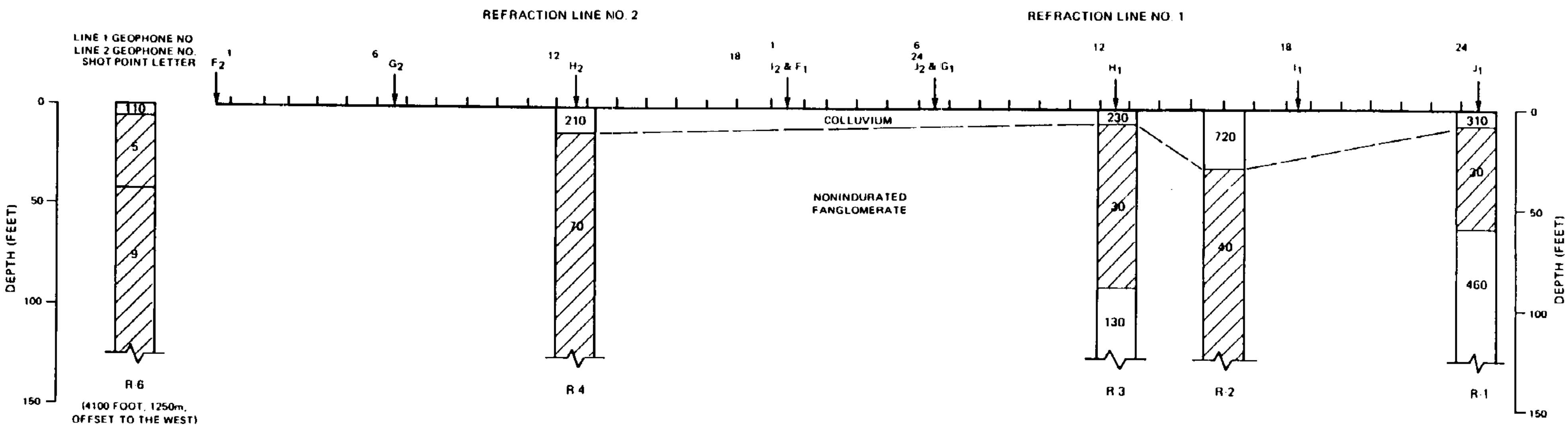
Sounding R-6 shows a thick, low resistivity layer near the surface which also corresponds with the fanglomerate layer. The seismic velocity of this layer is 2900 fps (884 mps) which is well below the characteristic value for water. Therefore, if any saturated zones exist under the east-west refraction line, they must be small and isolated.

D-4 INTEGRATION OF RESULTS

The refraction/resistivity surveys have indicated answers to the questions posed in D-3.1.3.

1. Nature of Outcrop

   The northern rock outcrop is the surface expression of a much larger rock mass. The measured seismic velocity of the rock is 12,000 fps (3658 mps), which is within the range of velocities typically measured in carbonate rock.



EXPLANATION

R 1 — ELECTRICAL RESISTIVITY SOUNDING LOCATION

SHADING REPRESENTS LOW RESISTIVITY ZONE

ALL ELECTRICAL RESISTIVITY VALUES ARE IN OHM METERS

ONE DIMENSIONAL ELECTRICAL RESISTIVITY MODELS ARE SHOWN AS EXAGGERATED COLUMNS FOR CLARITY ONLY

NOTE: ROCK OUTCROP APPROXIMATELY 300 FEET (91m) TO THE NORTH OF SHOT POINT J_1

NORTH

HORIZONTAL DISTANCE SCALE 1:6000

0 500 1000 FEET

0 300 METERS

VERTICAL DEPTH SCALE 1:600

0 50 100 FEET

0 30 METERS

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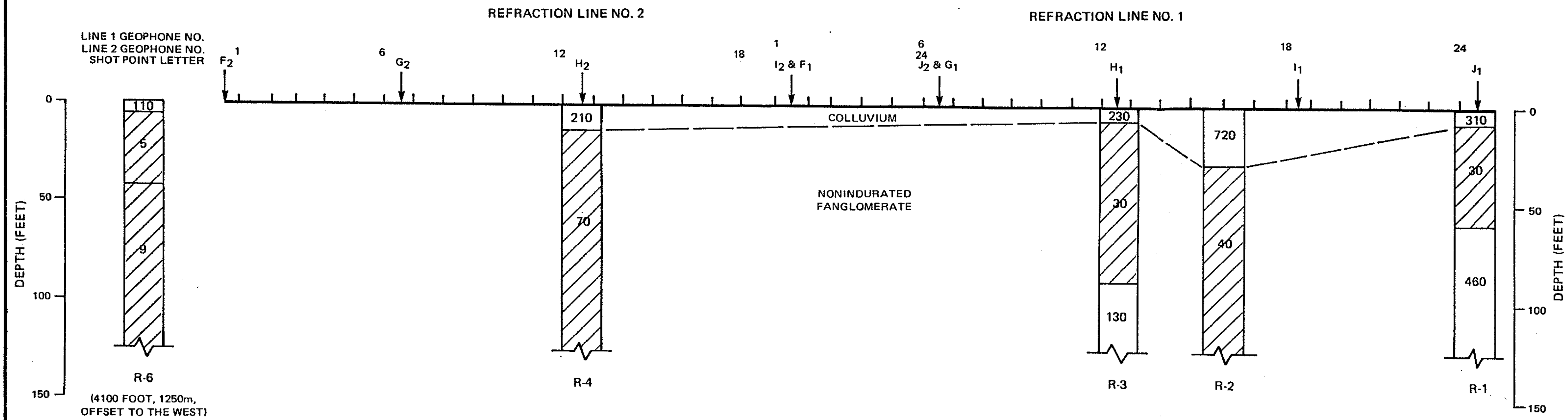
ELECTRICAL RESISTIVITY
CROSS SECTION
TOOELE, UTAH

6 82

FIGURE 12



HORIZONTAL DISTANCE SCALE 1:6000

0 500 1000 FEET

0 300 METERS

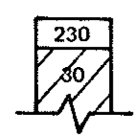
VERTICAL DEPTH SCALE 1:600

0 50 100 FEET

0 30 METERS

EXPLANATION

R-1 ELECTRICAL RESISTIVITY SOUNDING LOCATION



SHADING REPRESENTS LOW RESISTIVITY ZONE

ALL ELECTRICAL RESISTIVITY VALUES ARE IN OHM METERS

ONE DIMENSIONAL ELECTRICAL RESISTIVITY MODELS ARE SHOWN AS EXAGGERATED COLUMNS FOR CLARITY ONLY

NOTE: ROCK OUTCROP APPROXIMATELY 300 FEET (91m) TO THE NORTH OF SHOT POINT J_1

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ELECTRICAL RESISTIVITY
CROSS SECTION
TOOELE, UTAH

6-82

FIGURE 12

2. Bedrock Surface

The rock surface dips towards the south in a series of terraces. The three terraces are probably separated by two fault zones (Figure 3). The average depths of the terraces beneath the seismic line are:

- 180 feet (55 m) northern terrace
- 400 feet (122 m) central terrace
- 950 feet (290 m) southern terrace

The carbonate rock is not detected by the east-west refraction line which is 1800 feet (549 m) south of the north-south line. The depth to which we could exclude the rock under this line was calculated to be 1270 feet (387 m).

3. Overburden Layering

There are three distinct subsurface velocity layers overlying the bedrock. They correlate with:

Colluvium -	mostly unconsolidated sands, silts and gravel.
Non-indurated fanglomerate -	a variable-cobble matrix filled with unconsolidated, fine-grained material.
Cemented conglomerate -	a variable-cobble matrix filled with cemented fine-grained material.

The inhomogeneity in the colluvium is expressed in the wide range of observed velocities, 1100 to 2200 fps (335 to 671 mps). The zone of non-indurated fanglomerate has a velocity ranging from about 5100 fps (1554 mps) on the N-S line to 2900 fps (884 mps) on the E-W line. The cemented conglomerate also has a higher velocity (9100 to 9400 fps; 2774-2865 mps) beneath the N-S line than it does beneath the E-W line, 7700 fps (2347 mps). The differences in the velocity layering between the two lines may be caused by anisotropy, differences in the materials, differences in the moisture content, or a combination of these factors.

4. Geologic Structures

Several structural features are interpreted from the refraction survey. Two bedrock fault zones are interpreted beneath the north-south refraction lines. They are located approximately 2000 and 6000 feet (610 and 1829 m) south of the outcrop. The approximate vertical offsets on the faults are:

150 feet (46 m) northern fault zone
550 feet (168 m) southern fault zone

The east-west line was positioned to cross a large gravity gradient which might indicate a fault. The seismic data indicates a vertical offset in the 7700 fps layer near the center of line 3B, which is also near the gravity gradient. The offset in this layer is on the order of 40 feet (12 m) but it could be caused by a larger displacement in the bedrock. Bedrock structure at this location is too deep to be determined by the refraction line geometry.

Another structure is indicated by the velocity anomaly in the fanglomerate material at the center of the north-south line. The velocity of the anomaly is 6800 fps (2073 mps) which is about 33 percent higher than the velocity of the surrounding material. The cause of the anomaly is interpreted to be a buried stream channel. The base of the channel is about 700 feet (213 m) wide and about 300 feet (91 m) below the surface. The higher velocity may indicate that material in the channel is much coarser than the surrounding material.

5. Water Saturated Zones

The results of the two surveys indicate that there may be a perched water zone beneath the north-south line, but no significant ground water under the east-west line. The perched water zone may exist at the north-south line because of well-developed cementation of the underlying conglomerate. The fact that the velocity in this zone is higher than it is beneath the east-west line indicates better cementation beneath the north-south line.

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D-5 Horizontal and Vertical Control Results

TOOELE ARMY DEPOT / NORTH
LAMBERT - UTAH CENTRAL

LATITUDE	LONGITUDE	NORTHING	EASTING	WELL #
40 32 35.292	112 21 40.463	806,047.120	1,760,638.300	N-2B
- 0 33 06.090	CONVERGENCE	0.9999752 SCALE FACTOR		
4679.190	ELEVATION	0.9997870 GRID FACTOR		
40 32 30.707	112 21 37.981	805,581.300	1,760,825.480	N-2C
- 0 33 04.500	CONVERGENCE	0.9999749 SCALE FACTOR		
4682.980	ELEVATION	0.9997866 GRID FACTOR		
40 30 22.604	112 23 48.214	792,717.360	1,750,641.410	N-3A
- 0 34 27.925	CONVERGENCE	0.9999674 SCALE FACTOR		
4726.820	ELEVATION	0.9997774 GRID FACTOR		
40 30 22.581	112 23 48.087	792,714.920	1,750,651.210	N-3B
- 0 34 27.843	CONVERGENCE	0.9999674 SCALE FACTOR		
4727.070	ELEVATION	0.9997774 GRID FACTOR		
40 31 47.074	112 21 54.903	801,178.630	1,759,476.340	N-4
- 0 33 15.340	CONVERGENCE	0.9999723 SCALE FACTOR		
4664.450	ELEVATION	0.9997847 GRID FACTOR		
40 30 03.267	112 27 41.754	790,948.050	1,732,581.600	N-6
- 0 36 57.525	CONVERGENCE	0.9999663 SCALE FACTOR		
5094.340	ELEVATION	0.9997616 GRID FACTOR		
40 29 33.942	112 22 12.876	787,720.530	1,757,957.540	N-7
- 0 33 26.853	CONVERGENCE	0.9999647 SCALE FACTOR		
4854.370	ELEVATION	0.9997696 GRID FACTOR		
40 33 50.598	112 23 22.327	813,744.460	1,752,850.250	N-8A
- 0 34 11.342	CONVERGENCE	0.9999798 SCALE FACTOR		
4474.530	ELEVATION	0.9997997 GRID FACTOR		
40 33 50.598	112 23 22.545	813,744.610	1,752,833.470	N-8B
- 0 34 11.482	CONVERGENCE	0.9999798 SCALE FACTOR		
4474.940	ELEVATION	0.9997997 GRID FACTOR		

TOODELE ARMY DEPOT / NORTH
U.T.M.- ZONE # 12

LATITUDE	LONGITUDE	NORTHING	EASTING	WELL #
40 32 35.292	112 21 40.463	4,488,722.030	384,726.049	N-2B
- 0 53 05.747	CONVERGENCE	0.9997635 SCALE FACTOR		
4679.190	ELEVATION	0.9995398 GRID FACTOR		
40 32 30.707	112 21 37.981	4,488,579.753	384,782.252	N-2C
- 0 53 04.050	CONVERGENCE	0.9997633 SCALE FACTOR		
4682.980	ELEVATION	0.9995394 GRID FACTOR		
40 30 22.604	112 23 48.214	4,484,677.706	381,656.041	N-3A
- 0 54 26.357	CONVERGENCE	0.9997723 SCALE FACTOR		
4726.820	ELEVATION	0.9995463 GRID FACTOR		
40 30 22.581	112 23 48.087	4,484,676.950	381,659.019	N-3B
- 0 54 26.274	CONVERGENCE	0.9997723 SCALE FACTOR		
4727.070	ELEVATION	0.9995463 GRID FACTOR		
40 31 47.074	112 21 54.903	4,487,240.514	384,363.336	N-4
- 0 53 14.263	CONVERGENCE	0.9997645 SCALE FACTOR		
4664.450	ELEVATION	0.9995415 GRID FACTOR		
40 30 03.267	112 27 41.754	4,484,170.537	376,149.382	N-6
- 0 56 57.728	CONVERGENCE	0.9997887 SCALE FACTOR		
5094.340	ELEVATION	0.9995452 GRID FACTOR		
40 29 33.942	112 22 12.876	4,483,142.053	383,876.674	N-7
- 0 53 23.526	CONVERGENCE	0.9997659 SCALE FACTOR		
4854.370	ELEVATION	0.9995338 GRID FACTOR		
40 33 50.598	112 23 22.327	4,491,081.449	382,366.442	N-8A
- 0 54 13.370	CONVERGENCE	0.9997703 SCALE FACTOR		
4474.530	ELEVATION	0.9995563 GRID FACTOR		
40 33 50.598	112 23 22.545	4,491,081.530	382,361.315	N-8B
- 0 54 13.512	CONVERGENCE	0.9997703 SCALE FACTOR		
4474.940	ELEVATION	0.9995563 GRID FACTOR		

TOOELE ARMY DEPOT / NORTH
LAMBERT - UTAH CENTRAL

LATITUDE	LONGITUDE	NORTHING	EASTING	SAMPLE #
40 30 21.268	112 23 47.420	792,581.500	1,750,701.400	NSW-1
- 0 34 27.416	CONVERGENCE	0.9999673 SCALE FACTOR		
0.000	ELEVATION	0.9999673 GRID FACTOR		
40 32 31.634	112 21 40.319	805,676.900	1,760,645.900	NSW-2
- 0 33 05.998	CONVERGENCE	0.9999749 SCALE FACTOR		
0.000	ELEVATION	0.9999749 GRID FACTOR		
40 31 37.960	112 21 49.740	800,252.600	1,759,866.100	NSW-3
- 0 33 12.033	CONVERGENCE	0.9999718 SCALE FACTOR		
0.000	ELEVATION	0.9999718 GRID FACTOR		
40 30 14.825	112 26 09.309	792,041.900	1,739,734.900	NSD-1
- 0 35 58.307	CONVERGENCE	0.9999670 SCALE FACTOR		
0.000	ELEVATION	0.9999670 GRID FACTOR		
40 33 48.038	112 25 27.387	813,583.200	1,743,196.000	NSD-2
- 0 35 31.453	CONVERGENCE	0.9999796 SCALE FACTOR		
0.000	ELEVATION	0.9999796 GRID FACTOR		
40 32 31.634	112 21 40.319	805,676.900	1,760,645.900	NSD-3
- 0 33 05.998	CONVERGENCE	0.9999749 SCALE FACTOR		
0.000	ELEVATION	0.9999749 GRID FACTOR		

TOOELE ARMY DEPOT / NORTH

U.T.M.- ZONE # 12

LATITUDE	LONGITUDE	NORTHING	EASTING	SAMPLE #
40 30 21.268	112 23 47.420	4,484,636.216	381,674.077	NSW-1
- 0 54 25.816	CONVERGENCE	0.9997723 SCALE FACTOR		
0.000	ELEVATION	0.9997723 GRID FACTOR		
40 32 31.634	112 21 40.319	4,488,609.186	384,727.694	NSW-2
- 0 53 05.587	CONVERGENCE	0.9997635 SCALE FACTOR		
0.000	ELEVATION	0.9997635 GRID FACTOR		
40 31 37.960	112 21 49.740	4,486,957.610	384,480.466	NSW-3
- 0 53 10.742	CONVERGENCE	0.9997642 SCALE FACTOR		
0.000	ELEVATION	0.9997642 GRID FACTOR		
40 30 14.825	112 26 09.309	4,484,491.178	378,331.218	NSD-1
- 0 55 57.887	CONVERGENCE	0.9997821 SCALE FACTOR		
0.000	ELEVATION	0.9997821 GRID FACTOR		
40 33 48.038	112 25 27.387	4,491,049.484	379,424.190	NSD-2
- 0 55 34.676	CONVERGENCE	0.9997789 SCALE FACTOR		
0.000	ELEVATION	0.9997789 GRID FACTOR		
40 32 31.634	112 21 40.319	4,488,609.186	384,727.694	NSD-3
- 0 53 05.587	CONVERGENCE	0.9997635 SCALE FACTOR		
0.000	ELEVATION	0.9997635 GRID FACTOR		

TOOELE ARMY DEPOT / SOUTH

LAMBERT - UTAH CENTRAL

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      LATITUDE      LONGITUDE                NORTHING            EASTING    WELL #
-----------------------------------------------------------------------------------
  40 17 21.978 112 19 22.208            713,531.220     1,770,461.390    S-2
-  0 31 37.527 CONVERGENCE          0.9999302 SCALE FACTOR
      5148.420 ELEVATION            0.9997239 GRID  FACTOR

  40 17 50.948 112 22 20.463            716,593.320     1,756,677.580    S-3
-  0 33 31.713 CONVERGENCE          0.9999313 SCALE FACTOR
      5053.630 ELEVATION            0.9997288 GRID  FACTOR

  40 15 44.336 112 19 14.667            703,646.170     1,770,955.030    S-4
-  0 31 32.696 CONVERGENCE          0.9999266 SCALE FACTOR
      5066.640 ELEVATION            0.9997237 GRID  FACTOR

  40 15 43.909 112 19 42.724            703,623.070     1,768,779.690    S-5
-  0 31 50.669 CONVERGENCE          0.9999266 SCALE FACTOR
      5052.070 ELEVATION            0.9997242 GRID  FACTOR

  40 15 58.659 112 21 45.648            705,205.600     1,759,265.330    S-6
-  0 33 09.412 CONVERGENCE          0.9999271 SCALE FACTOR
      5039.930 ELEVATION            0.9997252 GRID  FACTOR

  40 16 21.838 112 21 00.702            707,517.530     1,762,771.550    S-7
-  0 32 40.620 CONVERGENCE          0.9999280 SCALE FACTOR
      5048.770 ELEVATION            0.9997257 GRID  FACTOR

  40 17 51.760 112 19 12.931            716,538.060     1,771,207.810    S-8
-  0 31 31.585 CONVERGENCE          0.9999314 SCALE FACTOR
      5190.180 ELEVATION            0.9997234 GRID  FACTOR

  40 16 14.999 112 19 17.013            706,750.400     1,770,801.650    S-9
-  0 31 34.199 CONVERGENCE          0.9999277 SCALE FACTOR
      5101.630 ELEVATION            0.9997234 GRID  FACTOR

  40 16 52.782 112 18 50.643            710,554.720     1,772,880.390    S-10
-  0 31 17.307 CONVERGENCE          0.9999291 SCALE FACTOR
      5125.600 ELEVATION            0.9997238 GRID  FACTOR
```

40 18 37.011 112 17 40.858		721,052.290	1,778,382.100	S-11
- 0 30 32.605	CONVERGENCE	0.9999332	SCALE FACTOR	
5353.780	ELEVATION	0.9997186	GRID FACTOR	
40 15 40.093 112 23 33.635		703,409.150	1,750,876.230	S-12
- 0 34 18.586	CONVERGENCE	0.9999264	SCALE FACTOR	
5054.360	ELEVATION	0.9997240	GRID FACTOR	
40 17 10.651 112 23 51.558		712,585.810	1,749,578.900	S-14
- 0 34 30.067	CONVERGENCE	0.9999298	SCALE FACTOR	
5039.130	ELEVATION	0.9997279	GRID FACTOR	
40 18 51.051 112 18 52.056		722,522.460	1,772,879.800	S-15
- 0 31 18.212	CONVERGENCE	0.9999337	SCALE FACTOR	
5315.140	ELEVATION	0.9997207	GRID FACTOR	

TOOELE ARMY DEPOT / SOUTH

U.T.M.- ZONE # 12

LATITUDE	LONGITUDE	NORTHING	EASTING	WELL #
40 17 21.978	112 19 22.208	4,460,511.704	387,556.718	S-2
- 0 51 19.796	CONVERGENCE	0.9997556 SCALE FACTOR		
5148.420	ELEVATION	0.9995094 GRID FACTOR		
40 17 50.948	112 22 20.463	4,461,468.967	383,361.543	S-3
- 0 53 15.631	CONVERGENCE	0.9997674 SCALE FACTOR		
5053.630	ELEVATION	0.9995258 GRID FACTOR		
40 15 44.336	112 19 14.667	4,457,498.459	387,689.907	S-4
- 0 51 13.201	CONVERGENCE	0.9997552 SCALE FACTOR		
5066.640	ELEVATION	0.9995130 GRID FACTOR		
40 15 43.909	112 19 42.724	4,457,495.198	387,026.955	S-5
- 0 51 31.332	CONVERGENCE	0.9997570 SCALE FACTOR		
5052.070	ELEVATION	0.9995155 GRID FACTOR		
40 15 58.659	112 21 45.648	4,457,994.065	384,130.261	S-6
- 0 52 51.070	CONVERGENCE	0.9997652 SCALE FACTOR		
5039.930	ELEVATION	0.9995242 GRID FACTOR		
40 16 21.838	112 21 00.702	4,458,692.494	385,202.791	S-7
- 0 52 22.426	CONVERGENCE	0.9997622 SCALE FACTOR		
5048.770	ELEVATION	0.9995208 GRID FACTOR		
40 17 51.760	112 19 12.931	4,461,426.705	387,789.456	S-8
- 0 51 14.319	CONVERGENCE	0.9997549 SCALE FACTOR		
5190.180	ELEVATION	0.9995068 GRID FACTOR		
40 16 14.999	112 19 17.013	4,458,444.713	387,648.586	S-9
- 0 51 15.257	CONVERGENCE	0.9997553 SCALE FACTOR		
5101.630	ELEVATION	0.9995114 GRID FACTOR		
40 16 52.782	112 18 50.643	4,459,600.412	388,268.688	S-10
- 0 50 58.868	CONVERGENCE	0.9997536 SCALE FACTOR		
5125.600	ELEVATION	0.9995085 GRID FACTOR		

40 18 37.011 112 17 40.858 - 0 50 15.532 CONVERGENCE 5353.780 ELEVATION	4,462,789.841 0.9997489 SCALE FACTOR 0.9994930 GRID FACTOR	389,983.639	S-11
40 15 40.093 112 23 33.635 - 0 54 00.545 CONVERGENCE 5054.360 ELEVATION	4,457,461.268 0.9997726 SCALE FACTOR 0.9995309 GRID FACTOR	381,570.567	S-12
40 17 10.651 112 23 51.558 - 0 54 13.818 CONVERGENCE 5039.130 ELEVATION	4,460,260.113 0.9997737 SCALE FACTOR 0.9995328 GRID FACTOR	381,191.224	S-14
40 18 51.051 112 18 52.056 - 0 51 01.851 CONVERGENCE 5315.140 ELEVATION	4,463,247.498 0.9997535 SCALE FACTOR 0.9994994 GRID FACTOR	388,309.437	S-15

TOOELE ARMY DEPOT / SOUTH
LAMBERT - UTAH CENTRAL

LATITUDE	LONGITUDE	NORTHING	EASTING	SAMPLE
40 16 05.592	112 21 35.185	705,899.300	1,760,083.100	SSW-1
- 0 33 02.709	CONVERGENCE	0.9999274 SCALE FACTOR		
0.000	ELEVATION	0.9999274 GRID FACTOR		
40 16 00.175	112 21 45.382	705,358.800	1,759,287.500	SSW-2
- 0 33 09.241	CONVERGENCE	0.9999272 SCALE FACTOR		
0.000	ELEVATION	0.9999272 GRID FACTOR		
40 15 44.267	112 18 56.084	703,626.000	1,772,395.500	SSD-1
- 0 31 20.792	CONVERGENCE	0.9999266 SCALE FACTOR		
0.000	ELEVATION	0.9999266 GRID FACTOR		
40 15 43.319	112 19 25.515	703,551.000	1,770,113.200	SSD-2
- 0 31 39.645	CONVERGENCE	0.9999265 SCALE FACTOR		
0.000	ELEVATION	0.9999265 GRID FACTOR		
40 18 23.589	112 22 48.890	719,917.600	1,754,507.600	SSD-3
- 0 33 49.923	CONVERGENCE	0.9999326 SCALE FACTOR		
0.000	ELEVATION	0.9999326 GRID FACTOR		
40 19 01.273	112 23 51.991	723,779.200	1,749,657.700	SSD-4
- 0 34 30.344	CONVERGENCE	0.9999342 SCALE FACTOR		
0.000	ELEVATION	0.9999342 GRID FACTOR		

TOOELE ARMY DEPOT / SOUTH

U.T.M.- ZONE # 12

LATITUDE	LONGITUDE	NORTHING	EASTING	SAMPLE #
40 16 05.592	112 21 35.185	4,458,204.034	384,380.681	SSW-1
- 0 52 44.430	CONVERGENCE	0.9997645 SCALE FACTOR		
0.000	ELEVATION	0.9997645 GRID FACTOR		
40 16 00.175	112 21 45.382	4,458,040.711	384,137.262	SSW-2
- 0 52 50.925	CONVERGENCE	0.9997652 SCALE FACTOR		
0.000	ELEVATION	0.9997652 GRID FACTOR		
40 15 44.267	112 18 56.084	4,457,489.804	388,128.838	SSD-1
- 0 51 01.186	CONVERGENCE	0.9997540 SCALE FACTOR		
0.000	ELEVATION	0.9997540 GRID FACTOR		
40 15 43.319	112 19 25.515	4,457,470.925	387,433.190	SSD-2
- 0 51 20.196	CONVERGENCE	0.9997559 SCALE FACTOR		
0.000	ELEVATION	0.9997559 GRID FACTOR		
40 18 23.589	112 22 48.890	4,462,485.821	382,706.079	SSD-3
- 0 53 34.622	CONVERGENCE	0.9997693 SCALE FACTOR		
0.000	ELEVATION	0.9997693 GRID FACTOR		
40 19 01.273	112 23 51.991	4,463,671.107	381,234.832	SSD-4
- 0 54 16.156	CONVERGENCE	0.9997736 SCALE FACTOR		
0.000	ELEVATION	0.9997736 GRID FACTOR		

Appendix E

Contamination Results

(Site Summary Forms)

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION Well 1-N

SITE TYPE Well

SCREENED INTERVAL 392'-400'; 406'-423'; 434'-470'; 475'-502'; 510'-520'; 573'604'; 630'-640'; 700'-743

DEPTH TO WATER (FEET) 380.6

GROUND ELEVATION (FEET) 4848.1

LOCATION 793,425 Northing, 1,763,675 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Existing well No. 1 in the North Area; located in maintenance area, south east quarter - sampled to obtain background water quality data

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
Well 1	381	ground water	pump	3/30/82	Ni, Zn, Cl, NO_3, SO_4, Cr, Pb, Na

Ertec
The Earth Technology Corporation

SITE SUMMARY SHEET — TOOELE ARMY DEPOT

SITE IDENTIFICATION: Well 2-N

SITE TYPE: Well

SCREENED INTERVAL: 390'-480'

DEPTH TO WATER (FEET): 389.0

GROUND ELEVATION (FEET): 4855.8 ft.

LOCATION: 802, 425 Northing, 1,767,875 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING: Existing Well No. 2 in North Area; located in maintenance area, northeast quarter - sampled to obtain background water quality data

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
Well 2	391	ground water	pump	3/30/82	Ni, Zn, Cl, NO_3, SO_4, Cr, Pb, Na

Ertec
The Earth Technology Corporation

SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION Well 4-N

SITE TYPE Well

SCREENED INTERVAL 638'-696'; 700'-775'

DEPTH TO WATER (FEET) 622

GROUND ELEVATION (FEET) 5015

LOCATION 796, 300, Northing, 1,731,450 Easting (Utah State Plane Central Zor

REASON FOR SAMPLING Existing Well No. 4, North Area; located on ridge near N-6 in south west quarter. Sampled to obtain background water quality data.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
Well 4	622	ground water	pump	3/31/82	Ni, Zn, Cl, NO_3, SO_4, Cr, Pb, Na,
					gross beta

Ertec
The Earth Technology Corporation

SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION: Well 5-N

SITE TYPE: Well

SCREENED INTERVAL:

DEPTH TO WATER (FEET): 340

GROUND ELEVATION (FEET): 4750 feet

LOCATION: 809, 332.61 Northing, 1,731,456.07 Easting (Utah State Plane Central Zone)

REASON FOR SAMPLING: Existing Well No. 5, North Area; located at Firing Range northwest quarter; sampled to obtain background water quality data.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
Well 5	340	ground water	pump	4/14/82	Ni, Zn, Cl, NO_3, SO_4, Cr, Cu, Pb, Na
Well5-R	340	ground water	pump	6/25/82	

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT.

SITE IDENTIFICATION Well 6-N (USGS-2)

SITE TYPE Well

SCREENED INTERVAL 375'-415'

DEPTH TO WATER (FEET) 247.73

GROUND ELEVATION (FEET) 4553

LOCATION 807,584.75 Northing, 1,752,526.29 Easting (Utah State Plane Central Zone)

REASON FOR SAMPLING Existing well No. 6, USGS well, near east boundary of Ammo area, northeast quarter; sampled to obtain background water quality data

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
Well 6	248	ground water	pump	4/4/82	Ni, Zn, Cl, NO_3, SO_4, Cr, Pb, Na

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT

SITE IDENTIFICATION Well 1-S

SITE TYPE Well

SCREENED INTERVAL 290'-404'

DEPTH TO WATER (FEET) 286.71

GROUND ELEVATION (FEET) 5398.4

LOCATION 727, 419 Northing; 1,770,796 Easting (Utah State Plane, Central Zor

REASON FOR SAMPLING Existing well No. 1, South area; located near north boundary Northeast quarter; sampled to obtain background water quality data.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
Well 1	287	ground water	pump	3/31/82	Ni, Zn, Cl, NO_3, SO_4, Cr, Pb, Na

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION Well 3-S

SITE TYPE

SCREENED INTERVAL

DEPTH TO WATER (FEET)

GROUND ELEVATION (FEET)

LOCATION

REASON FOR SAMPLING Existing well No. 3, South area; CAMDS well; sampled to obtain background water quality data.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
CAMDS	?	ground water	pump	4/15/82	Ni, Zn, Cl, F, SO_4, Cr, Cu, Pb, Na,
					gross beta

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-SD1

SITE TYPE ditch

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) not determined

LOCATION 792,041.9 Northing, 1,739,734.9 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Sediment sample taken from dry wash in bottom of flood control dam, to determine if any contaminants were migrating by surface water flow from the chemical range or demolition area.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-SD1	0.5	sediment	grab	4/3/82	NO_3, SO_4, Na

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-SD2

SITE TYPE ditch

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) not taken

LOCATION 813.593.2 Northing, 1,743,196.0 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Sediment sample taken from dry wash along northern boundary to determine if any contaminants were being carried across boundary by surface water flow.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-SD2	0.5	sediment	grab	4/3/82	SO_4, Na, As, Zn

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-SD3

SITE TYPE Pond

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) approx. 6" above sample

GROUND ELEVATION (FEET) not surveyed

LOCATION 805,676.9 Northing, 1,760,645.9 Easting (Utah State Plane Central Zone)

REASON FOR SAMPLING Sediment sample taken from Industrial Waste Pond to determine what contaminants precipitated and collected in sediment underlying the surface water.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-SD3	0.5	sediment	grab	4/4/82	Cl, F, PO_4, SO_4, Na, Ni, Zn

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT.

SITE IDENTIFICATION N-SD4

SITE TYPE Ditch

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) not determined

LOCATION Radiological storage area

REASON FOR SAMPLING Sampled sediment being carried out of radiological storage and disposal area to determine if any radionuclides were migrating in surface-water runoff.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-SD4	0.5	sediment	grab	5/26/82	None above LOD

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION S-SD1

SITE TYPE ditch

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) not determined

LOCATION 703,626.0 Northing; 1,772,395.50 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Sediment sample from dry wash on southern boundary to determine if contaminants were migrating in surface-water flow from Area 2 or from the burning grounds.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-SD1	0.5	sediment	grab	4/4/82	NO_3, PO_4, SO_4, Na, As, Zn

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION S-SD2

SITE TYPE ditch

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) Not determined

LOCATION 703.551.0 Northing, 1,770,113.20 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Sediment sample from dry wash on southern boundary between wells S-4 and S-5. Sample taken to determine if contaminants were migrating by surface-water runoff from burning area.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-SD2	0.5	sediment	grab	4/4/82	Cl, NO_3, SO_4, Na, As, Ni, Zn

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION S-SD3

SITE TYPE ditch

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) not taken

LOCATION 719,917.60 Northing; 1,754,507.60 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Sediment sample taken from drainage ditch coming from Area 10 on west side. Sampled to determine if any contaminants coming out at Area 10, dead coyote at site.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-SD3	0.5	sediment	grab	4/4/82	Cl, NO_3, SO_4, Na, As, Zn

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT.

SITE IDENTIFICATION S-SD4

SITE TYPE ditch

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) not taken

LOCATION 723,779.20 Northing; 1,749,657.70 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Sediment sample taken from drainage ditch in northwest quarter. Sample taken to determine if contaminants migrating across depot by surface-water flow.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-SD4	0.5	sediment	grab	4/4/82	Zn, Cl, SO_4, Na, As, Ni

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-SW1

SITE TYPE pond

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) surface water

GROUND ELEVATION (FEET) not taken, ground-surface level

LOCATION 792,581.50 Northing; 1,750,701.40 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Surface-water sample taken from laundry effluent near TNT washout pond. This effluent is the mechanism for carrying TNT down through unsaturated zone. Sample taken to determine contaminants and characterisitics of this effluent. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
NSW-1	0.5	surface water	grab	4/5/82	Ni, Zn, RDX, Cl, F, NO_3, SO_4, Cr, Cu, Pb
NSW1-R	0.5	surface water	grab	6/23/82	Na , 111TCE

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-SW2

SITE TYPE pond

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) surface water

GROUND ELEVATION (FEET) not taken, approx. 10' below ground surface

LOCATION 805,676.90 Northing; 1,760,645.90 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Surface-water sample taken from industrial waste pond directly above sediment sample. Sample taken to determine contaminants in pond and for comparison of concentrations found in water versus sediment in equilibrium with the water. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-SW2	0.5	surface water	grab	4/14/82	Ni, Zn, TETRYL*, RDX*, CYN, Oil/Grease
					Cl, F, NO_3, PO_4, Be, Cd, Cr, Cu,
					Pb, Na, 24DMPN
					* interferences present

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-SW3

SITE TYPE lagoon

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) surface water

GROUND ELEVATION (FEET) approx. 4665

LOCATION 800,252.60 Northing; 1,759,866.10 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Surface-water sample taken from northwest corner of sewage lagoon. Sample taken to determine contaminants in lagoon, because approx. 50 gpm leaking into aquifer. High value in Hazard Ranking system.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-SW3	0.5	surface water	grab	6/23/82	CYN, Cl, PO_4, SO_4, Na, gross beta,
					Zn, Cu, PHEND6

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT.

SITE IDENTIFICATION S-SW1

SITE TYPE pond

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) surface water

GROUND ELEVATION (FEET) not taken; ground level

LOCATION 705,899.30 Northing; 1,760,083.10 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Surface-water sample taken from crater. Sampled to determine if contaminants migrating across Depot by surface water runoff. This crater was a collection point for a large runoff area.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-SW1	0.5	surface water	grab	4/6/82	As, Ni, Zn, Cl, NO_3, SO_4, Cr, Cu, Pb
S-SW1R	0.5	surface water	grab	6/24/82	Ag, Na, gross alpha, gross beta

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The Earth Technology Corporation

SITE SUMMARY SHEET – TOOELE ARMY DEPOT.

SITE IDENTIFICATION S-SW2

SITE TYPE Surface Water

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) not taken, approx. same as level in Well S-6

GROUND ELEVATION (FEET) approx. same as water level in S-6

LOCATION 705,358.80 Northing; 1,759,287.50 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Surface-water sample taken from standing water in crater near Well S-6. This water is probably hydrologically connected to groundwater since it is at approximately same level as water in Well S-6. Sample taken to determine if contaminants in water and to compare to S-6.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-SW2	0.5	surface water	grab	4/15/82	Pb, Cl, F, SO_4, Cd, Cr, Cu, As,
					Ag, Na, gross alpha

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The Earth Technology Corporation

SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION: S-SW3

SITE TYPE: ditch

SCREENED INTERVAL: N/A

DEPTH TO WATER (FEET): surface water

GROUND ELEVATION (FEET): not taken; approximately ground level

LOCATION: not surveyed, west side of CAMDS

REASON FOR SAMPLING: Surface-water effluent from CAMDS. Sample taken to determine if any contaminants in CAMDS effluent. Very close to ground water here. Also, numerous dead rabbits discovered. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-SW3	0.5	surface water	grab	5/4/82	Zn, Cl, NO_3, PO_4, SO_4, Na, Cu

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT

SITE IDENTIFICATION N-1

SITE TYPE Surf

SCREENED INTERVAL N/A

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) not taken

LOCATION

REASON FOR SAMPLING Soil sample taken in northeast quarter of north area. Sample taken as first soil sample for Well N-1, which was deleted as unnecessary. This sample measures contaminants in upper soil from spill from industrial pond. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
GS-1	0.5	soil	grab	4/4/82	Cl, NO_3, PO_4, SO_4 , As, Ni, Zn

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-2A

SITE TYPE Bore

SCREENED INTERVAL grouted to surface

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) 4679.19

LOCATION 806,047.12 Northing; 1,760,638.30 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Boring drilled for soil samples and groundwater samples. Soil not suitable for analysis. Hit bedrock; no groundwater. Drilled to sample perched zone from industrial pond.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
NONE	TAKEN				

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-2B

SITE TYPE bore

SCREENED INTERVAL capped bore, no screen

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) 4679.19

LOCATION 806,047.12 Northing; 1,760,638.30 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Re-drilling of Boring N-2A. No samples suitable for collection.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
NONE TAKEN					

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-2C

SITE TYPE well

SCREENED INTERVAL 76.9 to 96.4

DEPTH TO WATER (FEET) 87.9

GROUND ELEVATION (FEET) 4681.1

LOCATION 805,581.30 Northing; 1,760,825 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well drilled to sample perched zone coming from seepage of industrial waste pond. Approximately 50 gpm seeping into ground. Very high value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-2C	93	ground water	pump	6/24/82	Cl, F, PO_4, Na, 2,4,6-TNT*
					As, Ni, Zn, Cr, Pb, 12DCLE, T12DCE,
					111TCE, TRCLE
					* interference present

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-3A

SITE TYPE well

SCREENED INTERVAL 297.8 feet to 337 feet (bottom of well)

DEPTH TO WATER (FEET) 4471.9 feet (from ground surface)

GROUND ELEVATION (FEET) 4726.82 feet (top of protective casing); 4723.9 (ground surface)

LOCATION 792,717.36 Northing; 1,750,641.41 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well N-3A is located down-gradient of the TNT washout ponds and is near an active effluent discharge. The TNT washout area was the second most important area for investigation as determined by the Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
GS-1	1.0	sediment	grab	2-27-82	Ni, Zn, Na, 2,4-DNT, 2,6-DNT* NO_3, PO_4, SO_4, 2,4,6-TNT, RDX
SS-3	10.75	soil	split spoon	2-27-82	RDX
SS-5	20.75	soil	split spoon	2-27-82	RDX
SS-7	30.75	soil	split spoon	2-27-82	none above LOD
SS-9	40.75	soil	split spoon	2-27-82	2,4,6-TNT
SS-11	50.75	soil	split spoon	2-27-82	2,4-DNT
SS-13	60.75	soil	split spoon	2-27-82	RDX
SS-15	70.75	soil	split spoon	2-27-82	RDX
SS-17	80.75	soil	split spoon	2-27-82	RDX
SS-19	90.75	soil	split spoon	2-27-82	RDX
SS-22	100.75	soil	split spoon	2-27-82	None above LOD
SS-30	138.75	soil	split spoon	2-27-82	None above LOD
N-3A	252	groundwater	pump	4-5-82	Ni, Zn, RDX, Cl, F, NO_3, SO_4, Cr, Pb Na, gross beta

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT

SITE IDENTIFICATION N-3B

SITE TYPE Well

SCREENED INTERVAL 36.8 to 56.4 feet

DEPTH TO WATER (FEET) 50.9

GROUND ELEVATION (FEET) 4724.1

LOCATION 792.714.92 Northing; 1,750,651.21 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well drilled to intercept perched zone discovered when drilling well N-3A. Sampled to determined contaminants in perched zone.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-3B	50.9 to 52.4	ground water	bailed	6-23-82	Cl, F, NO_3, SO_4, Na, Gross beta
					As, Zn, Cr, Cu, 46DN2C

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-4

SITE TYPE Well

SCREENED INTERVAL 193.1 to 208 feet

DEPTH TO WATER (FEET) 191.3 feet

GROUND ELEVATION (FEET) 4662.6

LOCATION 801,178.63 Northing; 1,759,476.34 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well N-4 is located 1200 feet north-northwest of the sewage lagoon. It is re-located and combined with N-1. Sampled to determine if contaminants in ground-water from sewage lagoon and landfill sources. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-4	196	ground water	pump	6/24/82	Cl, F, NO_3, SO_4, Na, Gross beta
					Ni, Zn, TRCLE

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-6

SITE TYPE Well

SCREENED INTERVAL 633.1 to 692 feet

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) 5091.9

LOCATION 790,948.05 Northing; 1,732,581.60 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING N-6 is located on ridge overlooking chemical range. Drilled to sample chemical range, burning areas, and demolition range. Well dry- drilled to 704 feet.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
	NONE TAKEN				

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION N-7

SITE TYPE bore

SCREENED INTERVAL capped bore, no screen

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) 4853.3

LOCATION 787,720.53 Northing; 1,757,957.54 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well N-7 was drilled on the southern boundary to determine background concentrations coming across boundary from chemical operations near Stockton Bar. Well not complete - low priority.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
	NONE TAKEN.				

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT.

SITE IDENTIFICATION N-8A

SITE TYPE well

SCREENED INTERVAL 53.9 to 73.6 feet

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) 4471.9

LOCATION 813,744.46 Northing; 1,752,850.25 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well N-8A drilled along north boundary to locate possible perched zone possibly resulting from Industrial Waste Pond. Well dry - no perched zone.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
	NONE TAKEN				

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION: N-8B

SITE TYPE: well

SCREENED INTERVAL: 240.73 to 280.0 feet, 181.76 to 201.37 feet

DEPTH TO WATER (FEET): 168.9 feet

GROUND ELEVATION (FEET): 4472.3

LOCATION: 813,744.61 Northing; 1,752,833.47 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING: Well N-8B is on northern boundary. This well was drilled to sample water leaving boundary at Depot in area most likely to be contaminated. Two separate screens placed to sample two possibly separate aquifers.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
N-8B-1	190	ground water	pump	5/3/82	Ni, Zn, Oil/Grease, Cl, NO_3, SO_4, Na, Cr
N-8B-2	260	ground water	pump	5/3/82	Ni, Zn, Cl, NO_3, SO_4, Na, Cr

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION S-1

SITE TYPE well

SCREENED INTERVAL 10.3 to 20.2 feet

DEPTH TO WATER (FEET) 8.0 feet

GROUND ELEVATION (FEET) approx. 5038

LOCATION 711,679.69 Northing; 1,758,523.04 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-1 is located downgradient from the CAMDS facility effluent. It is sampled to determine if any contaminants are entering the groundwater from the effluent and if any previous contamination is present and being leached into the ground-water. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
SS-2	5.8	soil	splitspoon	5/27/82	Cl, SO_4, Na, As, Ni, Zn, DEP
SS-3	10.6	soil	splitspoon	5/27/82	Cl, SO_4, Na, Zn, As , DEP
SS-4	15.6	soil	splitspoon	5/27/82	Cl, SO_4, Na, As, Zn
SS-5b	20.7	soil	splitspoon	5/27/82	Cl, F, SO_4, Na, As, Zn, DEP
S-1	12	ground water	pump	6/24/82	Be, Cu, Na, Cr CYN, Ca, F, NO_3, SO_4, gross beta, As
S-1dup	12	ground water	pump	6/24/82	

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION S-2

SITE TYPE well

SCREENED INTERVAL 56.5 to 76.2 feet

DEPTH TO WATER (FEET) 57.8 feet

GROUND ELEVATION (FEET) 5145.6

LOCATION 713,531.22 Northing; 1,770,461.39 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-2 ranked high in our Hazard Ranking System because of a no-longer-existing pond and Bldg. T-600 where there was a very high probability of contamination.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
SS-2	5.5	soil	splitspoon	2/19/82	Zn, Cl, NO_4, PHEND6, Na
SS-6A	25.3	soil	splitspoon	2/19/82	Cl, NO_3, Zn, Na
SS-10	45.8	soil	splitspoon	2/19/82	Cl, NO_3, Zn, Na
S-2	65	ground water	pump	4/29/82	Zn, Cl, NO_3, SO_4, Na, gross alpha, Cr

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT.

SITE IDENTIFICATION S-3

SITE TYPE well

SCREENED INTERVAL 24.0 - 43.6 feet

DEPTH TO WATER (FEET) 26.85 feet

GROUND ELEVATION (FEET) 5051.3

LOCATION 716,593.32 Northing; 1,756,677.58 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-3 is located on the south boundary of Area 10. Groundwater was sampled to determine if contaminants were leaching from the gravel pit inside Area 10 where mustard was burned and buried. High value in Hazard Ranking System .

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-3	32	ground water	pump	4/29/82	As, Ni, Zn, Cl, F, SO_4, Na, gross beta

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION S-4

SITE TYPE well

SCREENED INTERVAL 64.0 to 83.6 feet

DEPTH TO WATER (FEET) 58.3

GROUND ELEVATION (FEET) 5064.0

LOCATION 703,646.17 Northing; 1,770,955.03 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-4 is located on the southern boundary due south of the burning or demilitarization area. Samples taken from Well S-4 monitor the groundwater immediately before leaving the depot. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-4	58.4 to 61.0	ground water	bail	5/2/82	As, Zn, Cl, F, SO_4, Na, gross beta

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT

SITE IDENTIFICATION S-5

SITE TYPE well

SCREENED INTERVAL 37.6 to 57.6 feet

DEPTH TO WATER (FEET) 71.5 feet

GROUND ELEVATION (FEET) 5048.6

LOCATION 703,623.07 Northing; 1,768,779.69 Easting, (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-5 is located on the southern boundary due south of the burning or demilitarization area. Samples taken from Well S-5 monitor the ground water immediately before leaving the depot. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-5	42	ground water	pump	5/2/82	As, Zn, Cl, F, NO_3, SO_4, Na, gross beta

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT.

SITE IDENTIFICATION S-6

SITE TYPE well

SCREENED INTERVAL 15.25 to 34.93 feet

DEPTH TO WATER (FEET) 17.3 feet

GROUND ELEVATION (FEET) 5036.9

LOCATION 705,205.60 Northing; 1,759,265.33 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-6 was drilled among the high explosive test craters to determine if any contaminants are entering the ground water from these sources. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-6	25	ground water	pump	4/28/82	As, Zn, Cl, F, SO_4, Na, gross beta

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT.

SITE IDENTIFICATION S-7

SITE TYPE well

SCREENED INTERVAL 32.0 to 51.61 feet

DEPTH TO WATER (FEET) 26.5 feet

GROUND ELEVATION (FEET) 5045.9

LOCATION 707,517.53 Northing; 1,762,771.55 Easting (Utah State Plane Central Zone)

REASON FOR SAMPLING Well S-7 is located among the high explosive-test craters and also downdradient from the windrows where explosives and other materials were burned and buried. High value in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-7	35	ground water	pump	5/4/82	As, Ni, Zn, Cl, F, NO_3, SO_4, Na, gross beta

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION S-8

SITE TYPE well

SCREENED INTERVAL 65.0 to 84.6 feet

DEPTH TO WATER (FEET) 73.9 feet

GROUND ELEVATION (FEET) 5187.4

LOCATION 716,538.06 Northing; 1,771,207.81 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-8 is located south of Bldg. 553. It was drilled to determine if contamination has occurred from the operations from Bldgs. 554 and 553, the holding pond (dry) at Bldg 554, and the current effluent from Bldg. 553.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
SS-4	15.7	soil	splitspoon	3/2/82	Cl, SO_4, PHEND6, Na, As, Ni, Zn
SS-9	40.8	soil	splitspoon	3/2/82	Cl, F, NO_3, SO_4, Na, As, Ni, Zn
SS-12	55.8	soil	splitspoon	3/2/82	Cl, PHEND6, Na, As, Zn
SS-14	65.5	soil	splitspoon	3/2/82	Cl, NO_3, SO_4, Na, Zn
SS-17	80.5	soil	splitspoon	3/2/82	Cl, NO_3, DEP, Na, Zn
S-8	80	ground water	pump	5/4/82	Zn, Cl, NO_3, SO_4, Na

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT.

SITE IDENTIFICATION S-9

SITE TYPE bore

SCREENED INTERVAL capped bore - no screen

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) 5098.1

LOCATION 706,750.40 Northing; 1,770,801.65 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Boring S-9 was originally drilled to monitor ground water entering the Demilitarizing Area from Area 2, to determine the background level of contaminants entering this area. Reached 110 feet and discontinued drilling because did not reach ground water.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
	NONE TAKEN				

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT

SITE IDENTIFICATION S-10

SITE TYPE well

SCREENED INTERVAL 70.0 to 89.6 feet

DEPTH TO WATER (FEET) 67.7 feet

GROUND ELEVATION (FEET) 5122.5

LOCATION 710,554.72 Northing; 1,772,880.39 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-10 was drilled downgradient of Area 2 and several chemical and agent spills to determine if any contamination occurred from these sources. High rank in Hazard Ranking System.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-10	75	ground water	pump	5-2-82	Zn, Cl, NO_3, SO_4, Na, Cr

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT.

SITE IDENTIFICATION S-11

SITE TYPE bore

SCREENED INTERVAL grouted to surface

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) 5350.2

LOCATION 721,052.29 Northing; 1,778,382.10 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Boring S-11 was drilled to monitor the unsaturated zone near the new sanitary landfill to determine if contaminants were migrating towards the water table.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
CS-1	17.5	soil	splitspoon	2/22/82	Cl, NO_3, SO_4, PHEND6, Zn, Na
CS-2	37.0	soil	splitspoon	2/22/82	Cl, NO_3, SO_4, PHEND6, Zn, Na
SS-16	76.2	soil	splitspoon	2/22/82	Zn, Cl, SO_4, Na

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SITE SUMMARY SHEET – TOOELE ARMY DEPOT

SITE IDENTIFICATION S-12

SITE TYPE well

SCREENED INTERVAL 34.0 to 38.9 feet

DEPTH TO WATER (FEET) 31.0 feet

GROUND ELEVATION (FEET) 5051.1

LOCATION 703,409.15 Northing; 1,750,876.23 Easting (Utah State Plane Central Zone)

REASON FOR SAMPLING Well S-12, originally designed as a cluster well, monitors groundwater flow off the depot at the most likely site of contamination from several upgradient sources including craters and CAMDS. Only one well drilled due to cost constraints. Also, Well S-12 is possibly in a ground water discharge area.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-12	30	ground water	bailed	4/28/82	As, Cl, F, NO_3, SO_4, Na, gross beta

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT

SITE IDENTIFICATION S-14

SITE TYPE well

SCREENED INTERVAL 12.0 to 31.6 feet

DEPTH TO WATER (FEET) 10.65 feet

GROUND ELEVATION (FEET) 5035.9

LOCATION 712,585.81 Northing; 1,749,578.90 Easting (Utah State Plane, Central Zone)

REASON FOR SAMPLING Well S-14 was drilled on the west boundary to monitor groundwater flow going off the depot downgradient of sources such as Area 10 and possibly CAMDS. Well S-14 is possibly in a groundwater discharge area.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
S-14	15	ground water	pump	5/2/82	As, Ni, Zn, Oil/Grease, Cl, F, SO_4,
					Na, gross beta

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SITE SUMMARY SHEET — TOOELE ARMY DEPOT

SITE IDENTIFICATION S-15

SITE TYPE bore

SCREENED INTERVAL grouted to surface

DEPTH TO WATER (FEET) dry

GROUND ELEVATION (FEET) 5311.8

LOCATION 722,522.46 Northing; 1,772,879.80 Easting (Utah State Plane Central Zone)

REASON FOR SAMPLING Boring S-15 was drilled to determine if contaminants were leaching from the old landfill source. No samples suitable for analysis were collected.

FIELD SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SAMPLE TYPE	SAMPLE METHOD	DATE SAMPLED	CHEMICAL CONSTITUENTS (ABOVE LOD)
	NONE TAKEN				